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ACID RAIN AND RELATED AIR POLLUTION RESEARCH

**A Directory of USDA and State Projects
in CRIS**

Prepared by

Current Research Information System
Cooperative State Research Service

and

Information Systems Division
National Agricultural Library

U.S. DEPARTMENT OF AGRICULTURE

**United States
Department of
Agriculture**



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April 1987

CURRENT RESEARCH INFORMATION SYSTEM

The Current Research Information System (CRIS) is a computer-based information storage and retrieval system which documents and provides access to information on publicly supported agricultural and forestry research in the United States. CRIS is operated by the Cooperative State Research Service, U. S. Department of Agriculture.

The CRIS database consists of descriptions of research projects conducted or sponsored by the U. S. Department of Agriculture's research agencies, the State agricultural experiment stations and land-grant institutions, State forestry schools, Tuskegee University, U. S. schools of veterinary medicine, and participants in the competitive research grants program of the Department.

Approximately 30,000 ongoing and recently completed research projects are documented in CRIS. Some 5,000 new projects and revisions are entered in the system annually. Most projects remain active for 3-5 years and are retained in the file an additional two years beyond their termination date. Active projects are updated annually with progress reports and citations to the latest publications resulting from the research.

Retrieval of CRIS project information is provided to users worldwide through the publicly accessible CRIS online file (File 60) of DIALOG Information Services, Inc.

FOREWORD

This directory, "Acid Rain and Related Air Pollution Research," covers research dealing not only with acid rain, but also with projects on gaseous and other dry depositions. We believe it is important to document research in this broad context because these atmospheric phenomena do not occur in isolation from each other. There are undoubtedly numerous interactions, about which we have some small understanding.

It is hoped that this publication will serve as a research tracking aid and further help readers keep abreast of ongoing and recently completed research on this important topic. By taking advantage of the U. S. Department of Agriculture's Current Research Information System computerized database, as well as the Department's collaboration with the research network, we began in early 1986 to examine the contents of the database for relevancy to the topic and develop a research inventory that would be most useful to research scientists and administrators. User reactions to this directory are welcome; in fact, they are essential if this document is to be of greatest utility.

JOHN M. BARNES
COOPERATIVE STATE RESEARCH SERVICE
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

PREFACE

This directory is a listing of research projects on acid rain and the related effects of air pollutants on crops and livestock. Included are projects conducted or sponsored by the U.S. Department of Agriculture (USDA), the State agricultural experiment stations and land-grant institutions, the State forestry schools, and other cooperating State institutions. The projects were identified in March, 1986 and include research that was active as of October, 1982 and later.

The source for all projects listed in this directory was the Current Research Information System (CRIS), USDA's computer-based documentation and reporting system for publicly supported agricultural and forestry research in the United States. CRIS is operated by the Cooperative State Research Service, USDA.

Full project abstracts appear in this directory in the main entry section titled Research Project Descriptions. The section is divided into chapters based on commodity classifications used for classifying projects in the CRIS database. Abstracts appear in chapters that correspond to the original commodity classifications assigned when the projects were submitted for entry in CRIS. Projects assigned more than one commodity classification are repeated in each of the applicable chapters. Repeat entries are identified by an asterisk in the main entry section and in the indexes.

Arrangement of projects within chapters is alphabetical by State or country, followed in order by name of performing institutions, department and investigator.

The three indexes provided are the Keyword/Title Index, Investigator Index, and Performing Institution Index. Directory numbers in the indexes are used for locating projects in the main entry section. The two left-most digits correspond to the chapter in which the project is located and the three right-most digits indicate its position within the chapter.

Index terms in the Keyword/Title Index are the keywords originally assigned by CRIS primarily for use in computer retrieval. Project titles have been inserted to provide context.

The Investigator Index is an alphabetical listing of the principal and co-investigators reported on the projects.

The Performing Institution Index lists the names of the institutions alphabetically by city within State or country.

To obtain abstracts of projects that have started since this directory was prepared or for later updates of progress and publications on specific projects listed here, users may directly access the CRIS file via the DIALOG online retrieval system. CRIS is file 60 on DIALOG. The CRIS accession number shown opposite the directory number in the main entry section may be used with a TYPE or DISPLAY command on DIALOG to retrieve project information online at the user's terminal. Format 7 in the CRIS file carries both the narrative summary and the most recent update of progress and publication citations entered on the project to date. Projects remain on the CRIS file for two years beyond their termination date and are then purged. The file is updated monthly.

This directory was organized and edited by Richard M. Sparks of CRIS. Philip L. Dopkowski, Chief, Technical Products and Services, CRIS, provided overall project direction. Edward A. Warnick of the Information Systems Division of the National Agricultural Library provided technical assistance. John M. Barnes of the Cooperative State Research Service, USDA, was responsible for scientific oversight and support.

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RESEARCH PROJECT DESCRIPTIONS

CM 01 SOIL AND LAND

01.001 CRIS0095246
GEOGRAPHIC VARIATION IN CHEMICAL PROPERTIES OF
NEW ENGLAND FOREST SOILS.

TAYLOR R W; Natural Resources & Env Studis;
Alabama Agric and Mech Coll, Normal, ALABAMA
35762.

Proj. No.: ALAX-2-13-14-3100 Project Type: STATE
Agency ID: OCI Period: 01 SEP 84 to 01 OCT 86

Objectives: To measure and assess chemical
variability in the B horizons of New England
forest soils.

Approach: Soil samples from the B horizon of
forest soils from Maine, New Hampshire and
Vermont will be collected and available sodium,
calcium, potassium, phosphorus, extractable
aluminum and selected micronutrients
determined. The USDA Forest Service will
determine pH and exchangeable acidity and all
of the data will be used to identify forest
soils that may be susceptible to acid
precipitation.

01.002 CRIS006B137
GAS SORPTION BY SOILS

BOHN H L; Soil Water & Engineering; University
of Arizona, Tucson, ARIZONA 85721.
Proj. No.: ARZT-170663-H-21-42

Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 78 to 30 SEP 84

Objectives: Measure the ability of soils to
absorb and degrade pollutants in waste gases.
Estimate the soil's influence of atmospheric
CO(2) concentrations.

Approach: The absorption of pollutant gases
will be measured by using soils as the solid
phase of gas-solid chromatography. The
degradation of these pollutants will be
measured by adding such pollutants to soils in
the field. The soil's role in the controlling
CO(2) will be estimated by including its mass,
degradation rate, accumulation rate and climate
dependence to existing models of the carbon
cycle.

Progress: 75/07 to 84/09. In the laboratory
and the field, the soil's ability to remove
SO(2), NO(x), H(2)S, polyaromatic hydrocarbons,
propane, carbon monoxide, water mist, odors,
residential flue gases, and smoke was
investigated. The successful removal suggests
that soil beds are useful scrubbers of wastes
gases from residential heating and many

industrial processes.

Publications: 75/07 to 84/09
NO PUBLICATIONS REPORTED THIS PERIOD.

01.003 CRIS0089820
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS AND
MATERIALS

BOHN H L; Soil Water & Engineering; University
of Arizona, Tucson, ARIZONA 85721.
Proj. No.: ARZT-172950-R-21-36

Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of
atmospheric deposition on c) the chemical
composition of surface and ground waters.

Approach: The rainfall composition data
accumulated by the USDA personnel at their
Tombstone site since 1968 will be normalized
with later data gathered under the auspices of
Nc141. This data will be compared with the
sulfur emissions from the nearby and other
copper smelters in Arizona. The rainfall data
will also be related to the composition of the
runoff water into the San Pedro River from the
Tombstone Watershed.

Progress: 84/01 to 84/12. The western U.S.
has been subjected to sulfur emissions from the
smelting of lead, zinc, copper and other ores
for almost a century. The smelting has
decreased in the last decade due to low metal
prices and the mines playing out. The SO(2)
concentrations from smelting are high and
usually the chimneys are low. The local effects
on vegetation, however, appear to be minimal in
the arid regions of the West. In more humid
regions the total effect of the mining,
including tree harvest for fuel, housing, mine
timbers, as well as atmospheric emissions, has
been much more drastic. The effects are
reversible as indicated by the return of
vegetation after smelting ceased. The decreased
sulfur emissions from ore smelting is being
offset by recent increases in coal combustion
for electric power. The lower SO(2)
concentration and higher fly ash content and
taller smokestacks indicate that any sulfur
effects will be slight and difficult to
measure.

Publications: 84/01 to 84/12
BOHN, H.L. 1984. Potential affects of acid
deposition in the West. Air Pollut. Contr.
Assn., San Francisco, June 25.

01.004 CRIS0096913
EFFECTS OF ATMOSPHERIC DEPOSITION ON FOREST
RESOURCES IN ARKANSAS

BEASLEY R S; Forest Resources; University of
Arkansas, Monticello, ARKANSAS 71655.
Proj. No.: ARK01228

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 NOV 85 to 30 SEP 90

Objectives: To evaluate research programs designed to verify cause-effect relationships between forest decline and atmospheric deposition in Europe and the eastern U.S.; to characterize the current composition of precipitation, streamflow and soils in forest ecosystems in Arkansas and to determine the extent to which hydrologic processes; flow pathways and ecosystem characteristics modify or buffer acidic deposition; and measure long-term changes in atmospheric deposition and determine the effects of such changes on stream chemistry, aquatic organisms, soil properties and forest productivity.

Approach: Experimental forested watersheds in the Gulf Coastal Plain, the Athens Plateau and the Ouachita Mountains have provided detailed information on the hydrology and water chemistry of forest ecosystems in each physiographic province. These data will provide background information for expanding the work to evaluate effects of atmospheric deposition on forest soils, stream chemistry and forest productivity. Since measuring, sampling and collection devices are in place our initial work will involve additional soil and water chemical analyses such as sulfate, aluminum, pH and conductivity. The evaluation of flow pathways will require collection trenches to intercept and sample subsurface and overland flow. Initial work will be concentrated in the Ouachita Mountains where soils and streams are highly sensitive to acidification due to inherently low alkalinity.

01.005 CRIS0089881
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS AND
MATERIALS

BURGY R H; CARROLL J J; FLOCCHINI R G; Land,
Air & Water Resources; University of
California, Davis, CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-4311-RRProject Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America.

Approach: Studies will be conducted to identify and improve efficiency for collection of naturally- and anthropically-generated gaseous and particulate components added to, distributed by and deposited from the atmosphere which may have beneficial or injurious impact on components of terrestrial and aquatic ecosystems. Major sources and

composition of atmospheric pollutants and atmospheric processes involved in their distribution and deposition will be investigated.

Progress: 84/01 to 84/12. During 1984, the Davis site operated on a continuous basis to monitor precipitation deposition. This portion of the project is attempting to identify acidic deposition products contained in rain samples and to define the sources of acidic constituents that contribute to acidity of rainfall here. The program was modified on July 1, 1984 to discontinue collections of dry deposition samples (only a few stations in the U.S. will take dry samples hereafter). The Davis site was inspected by NADP this year and minor adjustments in equipment were made to conform to network specifications. A total of 20 rain samples were collected in the year, these yielding pH values ranging from 5.0 to 6.5. The average of all samples is about 5.8 pH units, indicating a nearly neutral acidity in Davis rainfall. Spring rains tend to have higher pH values (about 6.0) and Fall rains tend to be lower (5.0 to 5.5), suggesting some effect due to strong inflow in early winter storms that generally translate into the upper delta area (Davis) from the southwest and include trajectories passing over the metropolitan bay-delta region. The limited numbers of events sampled makes all interpretations inconclusive, and will require longer experience to resolve.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

01.006 CRIS0074466
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND
EFFECTS ON LAND AND SURFACE WATERS

BURGY R H; MYRUP L O; Land, Air & Water
Resources; University of California, Davis,
CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-3619-RRProject Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establishing an Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Developing optimum procedures for collecting precipitation (regular timed sampling and event sampling) and dry particulate matter (open containers, air-filtration collectors and biological collectors). Determining the stability of certain constituents of precipitation during collection, transport and storage prior to analysis. Investigating the transport and transformations of atmospheric constituents. Organizing and coordinating research is the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition.

Approach: For all objectives listed, utilizing a network sampling station and specifications developed by the Regional Project, the data

collection, processing analysis and interpretation will be adapted to project requirements. Special studies are to be devised in concert with project subcommittee coordination.

Progress: 79/09 to 83/09. The data acquisition site in the National Atmospheric Deposition Program has been operational since the Fall of 1979. During the first three years of operation only the rainfall season collections were made in the period of September through May. In 1982, the project operation was made to conform to the NADP standards and schedule with full seasonal data collection made weekly throughout the year. During the five years of records acquired at the station a trend is observable in the measured hydrogen ion concentration (pH) of sampled rainfall, tending to become more neutral with pH approaching 5.6. Occasional samples are measured with both higher and lower pH values. Improvement in the station operating procedures and in the handling and processing both in field and laboratory may account for some reduction in the occurrence of low pH values. Other factors may include improved environmental conditions upwind from the site due to reduced emissions of NO(x) compounds from metropolitan areas and possibly to general shifts in weather phenomena transporting the precipitation products into the region. Based on the record of the site, a general conclusion may be indicated toward low acidic precipitation input in that area of California. The project has been replaced by Inter-Regional Project IR-7, effective October, 1983.

Publications: 79/09 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

01.007 CRIS0066569
FIELD AND LABORATORY STUDIES OF NITROGEN TRANSFORMATIONS

DELWICHE C C; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.

Proj. No.: CA-D*-LAW-3204-H Project Type: HATCH
Agency ID: CSRS Period: 26 SEP 74 to 30 DEC 83

Objectives: Refine information on processes governing the cycling of nitrogen in soil and aquatic systems with particular reference to possibilities of water or air pollution and perturbations of natural nitrogen cycling processes.

Approach: Using isotopic nitrogen compounds to follow nitrogen transformations either in lysimeters, field tests or laboratory studies. Use high sensitivity chromatographic methods to detect oxides of nitrogen in deep profile and atmospheric gases.

Progress: 74/09 to 83/12. Evidence was obtained for the correlation of N(2)O production in soils as a function of fertilizer applications and other past management practice. Correlation of release of N(2)O soil with fluctuations in barometric pressure was demonstrated. Methods for gas chromatographic

determination of N(2)O were refined and tropospheric concentration determined, demonstrating concentration fluctuations as a function of soil properties. Information on N(2)O production in pure cultures was refined, comparing different organisms in their ability to utilize this gas as a terminal electron acceptor. Conditions affecting the survival of rhizobium in the water-logged soil of rice field were studied and the survival of this organism was shown to be dependent upon the microaerophylic condition provided by the rice plant. Lysimeter studies of fertilizer applications to range lands using isotopic nitrogen label gave quantitative information on the recovery of nitrogen fertilizer in plant material and the avenues of loss including leaching and volatilization. Nitrogen isotope distribution in native ecosystems was used as a means of tracing nitrogen movement in these systems. Mass spectrometric methods were refined and yielded new information regarding nitrogen inputs. Suspect species were examined and a new non-leguminous symbiotic nitrogen fixing plant-actinomycete association was demonstrated.

Publications: 74/09 to 83/12
HEISEY, R.M., DELWICHE, C.C., VIRGINIA, R.A., WRONA, A.F. and BRYAN, B.A. 1980. A new nitrogen-fixing non-legume: *Chamaebatia foliolosa* (Rosaceae). *American Journal of Botany* 67(3):429-431.
VIRGINIA, R.A. and DELWICHE, C.C. 1982. Natural ¹⁵N abundance of presumed N(2)-fixing and non-N(2)-fixing plants from selected ecosystems. *Oecologia* 54:317-325.
DELWICHE, C.C. 1982. Nitrogen Fertilizers. In: pp. 66-77. *Stratospheric Ozone and Man*, F. A. Bower and R. B. Ward (eds.). CRC Press, Boca Raton, Florida.
DELWICHE, C.C. 1982. Carbon Cycle. In: pp. 61-64. *The Encyclopedia of Soil Science Part 1* (1979), Fairbridge and Finkl (eds.). Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania, 18360.
DELWICHE, C.C. 1982. Nitrous oxide from soil. In: pp. 331-333. *McGraw-Hill Yearbook of Science and Technology 1982/1983*.

01.008 CRIS0088451
PEDOLOGIC INVESTIGATIONS IN SUPPORT OF ACID RAIN STUDIES, SEQUOIA NATIONAL PARK, CALIFORNIA

HUNTINGTON G L; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.

Proj. No.: CA-D*-LAW-4265-H Project Type: HATCH
Agency ID: CSRS Period: 30 AUG 82 to 30 SEP 86

Objectives: In cooperation with Sequoia National Park, project will: study, determine and map the vertical zonation patterns of soil subgroups on the watersheds between the Middle and Marble Forks of the Kaweah River; assist Park Service in using the data to select long term sites for base-line acid rain studies; provide detailed pedography for selected sites as part of evaluative base for ecological effects of acid rain.

Approach: A third order soil survey will be made within subject area. Dominant vegetation will be related to delineated soil subgroups. Orthophoto soil maps of the area will be made for guidance in meaningful selection of acid-rain study sites in the varied geologic and climatic zones within the Park. Detailed soil studies and maps will be made for the selected sites later.

Progress: 84/01 to 84/12. All soil map units reviewed and correlated in Soil Taxonomy for the ultra-detailed (Order 1) mapping of acid rain study sites, and for the reconnaissance (Order 4) mapping of the acid rain study region in Sequoia National Park. All laboratory soil characterization data reviewed and checked; descriptions of the sites and profiles prepared for all sampled reference pedons; data and descriptions assembled into 2 appendices for the project's report to the Park Service. Masters for the map printing plates prepared for the Order 4 map. Final map will consist of 7 sheets, scale 1:24000, on an orthophoto base. Sites selected for a special study transect of soil climate within the Sequoia NP acid study region. Special equipment has been obtained to initiate this study in the summer of 1985. Transect designed to look at soil-vegetation-elevation relationships to soil temperature and moisture regimes, as currently defined in Soil Taxonomy, in the mixed conifer to sub-alpine zones of the Sierra Nevada. No data currently exists. Needed to verify or modify classification of some of the soils in the Sequoia acid rain study region. Data also needed to correlate with other western regional soil climate studies.

Publications: 84/01 to 84/12

HUNTINGTON, G.L. and AKESDN, M. 1984. The Soils of Sequoia National Park: Ash Peaks Ridge to Triple Divide Peak. Abstracts of Presented Posters and Papers, Second Biennial Conf. of Research in California's National Parks.

01.009 CRIS0089880
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

WHITTIG L D; BURAU R G; HUNTINGTON G L; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
 Proj. No.: CA-D*-LAW-4312-RR Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Studies will evaluate sensitivity of soils, waters, and terrestrial and aquatic organisms to atmospheric deposition, chemical and biological processes in soils, waters and organisms affected by atmospheric deposition, and terrestrial processes and agricultural and forest practices as may influence effects of deposition on aquatic systems.

Progress: 84/01 to 84/12. Investigations under this project contribute to an integrated long-term study of potential impacts of atmospheric deposition on terrestrial and aquatic ecosystems of the Sierra Nevada. Centered in Sequoia National park, this project focuses on buffering characteristics of soils of the program study area, on release of chemical elements from the soils in response to acidity and alkalinity inputs, on mechanisms involved in dissolution and transport of mineral elements and on the input-output balance for sulfuric acid added to the soil systems. A total of 26 surface profile samples from representative soils have been subjected to a buffer performance test involving graded additions of H_2SO_4 and $Ca(OH)_2$. The pH of the systems was measured weekly for 6 weeks to observe the time course of buffering for each profile sample. Aqueous extracts from treated samples have been analyzed for major cations and anions. The pH data have been transformed into van Slyke buffering index curves and apparent sulfate adsorption has been calculated. The mineralogy has been qualitatively determined for silt and clay fractions of 12 of the surface profile samples. Buffering and sulfate adsorption have been unexpectedly strong in many samples while element release has been unexpectedly small. In addition to a wide diversity of phyllosilicate minerals in different soils of the area, there is a relatively high proportion of glass in a number of surface samples, suggesting a volcanic ash deposition source.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.010 CRIS0076189
ATMOSPHERIC INPUTS AND EFFECTS ON PLANTS AND SOILS

MCCDLL J G; Plant & Soil Biology; University of California, Berkeley, CALIFORNIA 94720.
 Proj. No.: CA-B*-PSB-3664-H Project Type: HATCH
 Agency ID: CSRS Period: 03 AUG 78 to 30 SEP 88

Objectives: Evaluate precipitation chemistry (primarily rain) in selected locations in northern California, and effects on plants and soil.

Approach: Sampling from eight locations will be made following rain storm events during 1978-79. Sample pH will be measured on-site, followed by full ionic analyses. Additional monitoring and experimentation will evaluate effects of chemical changes in precipitation due to air pollution on plant growth and soil properties.

Progress: 84/01 to 84/12. Effects of simulated acid rain on two range and three tree species, in two soils, were assessed over two years. Although there were no significant effects on plant growth, soil calcium decreased, while acidity, manganese, and aluminum increased. Only in some cases did soil nitrification decrease; denitrification and nitrogen mineralization increased with acid input; nitrogen fixation in clover was reduced by reduction in nodule number. Soil fertilizer additions ameliorated many of the acid effects noted in unfertilized soil. A simple method and model were also made, estimating relative sensitivity of soils to cation leaching by acid rain; sensitivity was largely a function of organic matter content and sum of exchangeable cations in the 26 test soils. Two kinetic models were also made which describe the dissolution of Al, Fe, Mn, and Mg from forest soils by soluble organic acids. The chemical structure, and the type and position of functional groups within a given organic chemical series were important factors in dissolution rates of Al, Fe, and Mn; Mg was mobilized by simple H hydrolysis rather than by chelation.

Publications: 84/01 to 84/12

- MCCOLL, J.G. and FIRESTONE, M.K. 1984. Cumulative effects of acid rain on plant productivity and soil nutrient supply under California conditions. Cal. Air Res. Board, Sacramento, Contract AD-134-33. 82 pp.
- POHLMAN, A.A. and MCCOLL, J.G. 1984. Mechanisms of Al, Fe, Mn and Mg dissolution from two forest soils, by soluble polyfunctional organic acids. Agron. Abstr. (76th Ann. Meet. Soil Sci. Soc. Am., Las Vegas, Nevada) p. 34.
- MCCOLL, J.G. 1984. Model of sensitivity of forest and range soils to acid rain. Agron. Abstr. (76th Ann. Meet. Soil Sci. Soc. Am., Las Vegas) p. 263.

01.011 CRIS0062810
UTILIZATION, CONVERSION, AND MANAGEMENT OF SOUTHERN CALIFORNIA BRUSHLAND

YOUNGNER V B; NUDGE F J; Botany & Plant Sciences; University of California, Riverside, CALIFORNIA 92521.
 Proj. No.: CA-R*-BPS-2861-H Project Type: HATCH
 Agency ID: CSRS Period: 03 OCT 72 to 31 MAR 84

Objectives: Develop a basis for brushland utilization and management through studies on potential uses of bursh species, effects of harvesting methods, substitution of exotic species, seedling establishment, competition among native and exotic species, physiology of resprouting.

Approach: Through field, greenhouse, growth chamber, and laboratory studies. Field studies will be in natural brushlands and field plantings, using portable research equipment. Laboratory analyses to plant tissue constituents and soil properties will be correlated with field observations. Specific environmental responses will be studied in

greenhouse and growth chambers.

Progress: 84/01 to 84/03. Investigations of annual range plant responses to the air pollutants O(3) and SO(2) were conducted in fumigation chambers. In *Bromus rubens* ozone both reduced yield and affected several aspects of quality. Sulfur dioxide effects were less and primarily involved quality factors. Interaction of the two pollutants was not shown. Chronic SO(2) exposure of *Bromus mollis* and *Erodium botrys* also resulted in yield reductions with carbohydrate allocation to the root zone being significantly reduced in *B. mollis*. *Erodium* growth showed some stimulation at the low SO(2) level but not at higher levels. Shoot sulfur content in *Bromus* was higher than in *Erodium* at comparable fumigation levels. Detrimental effects of fumigation were often not immediately apparent but developed as the season progressed. These studies indicated that air pollutants affect growth of brushland plants and may change species composition in affected areas. In some regions of high pollutant levels, value of the vegetation for forage and erosion control may be impaired and type conversion to species shown to be more tolerant may be desirable. Preparation of data for formal publication has continued.

Publications: 84/01 to 84/03

NO PUBLICATIONS REPORTED THIS PERIOD.

01.012 CRIS0011628
TRACE ELEMENT STUDY OF THE SOIL-PLANT-WATER SYSTEM

BRADFORD G R; PAGE A L; LUND L J; Soil & Environmental Sci; University of California, Riverside, CALIFORNIA 92521.
 Proj. No.: CA-R*-SES-1026-H Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 89

Objectives: The primary objectives are to detect potential trends toward acidification of Sierra Nevada lakes and patterns of chemical contamination of soils surrounding a generating station in the Mohave Desert.

Approach: One hundred and twenty-four Sierra Nevada lakes will be sampled by helicopter during the spring thaw and analyzed for pH, EC, and major cations and anions to monitor chemical changes which will reflect potential trends toward acidification. Surface and subsurface soils will be collected at different distances and directions annually, or as the data suggests, in the vicinity of a coal-fired generating station in the Mohave Desert and the aqueous extracts analyzed by a plasma direct reading spectrograph to monitor chemical contamination of the soil.

Progress: 84/01 to 84/12. Slight year to year variations pH and EC values in Sierra Nevada lake waters sampled annually the past 5 years appear to be the result of variations in seasonal snowfall. Both the pH and EC values decrease seasons of high snowfall probably because lake water is more like snow water during periods of heavy runoff. The mean total alkalinity (ANC) of lake waters was 34.7 mu

eq/L for 1984 compared to 35.4 mu eq/L for 1983, indicating the extreme sensitivity of the waters to acid input but showing no significant change during the past year. Elevated salt content, particularly Na, B, Mo and SO(4), was identified in saturation extracts of soil collected within 1.8km radius of a coal-fired electric generating station in the Mohave Desert in 1983 following 13 years operation.

Publications: 84/01 to 84/12

ELAMAMY, M.E., FOX, C.A., BRADFORD, G.R., PAGE, A.L., and NODVIN, S.C. 1984. The alkalinity of Pristine lakes in the High Sierra Mountains. Proceedings of Air pollution Control Association Meetings, San Francisco, California. June

01.013 CRIS0063536
CHARACTERIZATION OF SOILS AND LANDSCAPES AND INTERPRETATIONS OF THEIR GENESIS AND USE POTENTIALS

LUND L J; PAGE A L; Soil & Environmental Sci; University of California, Riverside, CALIFORNIA 92521.

Proj. No.: CA-R*-SES-2892 Project Type: STATE
 Agency ID: SAES Period: 01 MAR 73 to 30 SEP 86

Objectives: Contribute to knowledge about the distribution of soils and techniques for their mapping and contribute to the quantitative knowledge about soil characteristics and use potentials which will aid in resource management. Specifically determine the utility of applying remotely sensed Landsat data to soil survey in the desert southwest, determine how remotely sensed data can be used in resource management, determine genesis of selected soils of the southwest and investigate the potential impact of acid rainfall on soil resources of the southwest.

Approach: Spectral maps will be developed for selected areas in the desert southwest by digital analysis of Landsat data. These maps will be used in the field to determine their potential as an aid to soil survey and resource management. Soils of interest because of agricultural importance, uniqueness, areal extents or location will be characterized morphologically, physically, chemically and mineralogically. Interpretations will be made relative to soil genesis and use potential. The buffering capacities of benchmark and other important soils of the southwest will be determined for the acid rainfall study.

Progress: 84/01 to 84/12. Accomplishments during the past year can be reported in three areas. Studies on soil temperature regimes in the California deserts have continued. Data developed during the past year expanded our data base and improved our knowledge on the distribution of hyperthermic, thermic and mesic temperature regimes. These data were used to develop a soil temperature regime map for the California deserts that became part of a California map. Another project has been the development of a water shed study in the Sierra Nevada to evaluate nutrient and proton cycling in a representative terrestrial and aquatic

ecosystem. The Eastern Book Lakes watershed is the study area. Emphasis during the first year has been on monitoring lake, stream and precipitation chemistry. A soil processes project has been initiated at Emerald Lake watershed in Sequoia National Park. The objective of this study is to identify landscape elements where changes in water chemistry occur and to determine what soil characteristics and processes relate to these changes.

Publications: 84/01 to 84/12

AMUNDSON, R., and LUND, L.J. 1985. Changes in the chemical and physical properties of a reclaimed saline-sodic soil in the San Joaquin Valley of California. Soil Science. In Press.

AMUNDSON, R.G. 1984. A chronosequential evolution of the effects of reclamation on a saline-sodic soil. Ph.D. Thesis. Univ. of California, Riverside. 144pp.

01.014 CRIS0064880
CHEMICAL REACTIONS IN SOILS AND THEIR EFFECT ON PLANT GROWTH

LINDSAY W L; BOYLE F W JR; WALTHALL P M; Agronomy; Colorado State University, Fort Collins, COLORADO 80523.

Proj. No.: COLO0126 Project Type: HATCH
 Agency ID: CSRS Period: 07 OCT 83 to 30 JAN 88

Objectives: Seed a basic understanding of the inorganic chemical reactions that occur in soils. Apply chemical principles to product and interpret elemental solubility relationships in soils. Relate solubility relationships of chemical elements to plant growth, nutrient deficiencies, elemental toxicities, nutrient imbalances, selection and use of fertilizers, and the formation and weathering of soils.

Approach: Chemical data from the literature will be computerized and used to predict chemical reaction and solubility relationships in soils. These models will be tested experimentally. Missing critical data will be identified. Carefully planned experiments will be established to obtain the missing information. The findings will be used to correct existing problems and to plan future experiments.

Progress: 83/10 to 84/09. Acid rain research in Rocky Mountain National Park shows the formation of smectite minerals which depress A1 activity and allows the pH to drop into the range of 3.3 to 4.5. This is much lower than found in the Eastern U.S. where acidity problems are considered to be severe. Processed oil shales have undesirable pH values near 12. The high pH is the result of destructive loss of carbonates and formation of silicate minerals such as CaSiO(3) (wollastonite), CaMg(SiO(3))(2)(diopside), and MgSiO(3)(clinoenstatite). Recarbonation of such shales lowers the pH to 8.0 with the reformation of carbonate minerals. The effect of high pH and recarbonation on mineral transformations and solubilization of various metals ions is being studied. The cause of zinc

deficiency in paddy rice is under investigation. Reducing conditions resulting from flooding greatly increased the solubilities of Fe and Mn which have a depressing effect on the uptake of zinc. Reduction caused the precipitation of FeCO_3 (siderite) and $\text{Fe}(\text{OH})_3$ (ferrosic hydroxide), which raised the activity of Fe. We hypothesized that the increased activity of Fe depresses Zn activity through the formation for ZnFe_2O_4 (franklinite). This hypothesis will be examined further in subsequent studies. Activity measurements of Ca were made in both acid and calcareous soils. In calcareous soils Ca activities can be related to calcite equilibria.

Publications: 83/10 to 84/09

- LINDSAY, W.L. 1984. Soil and plant relationships associated with iron deficiency with emphasis on nutrient interactions. J. Plant Nut. 7:489-500.
- STUMPE, J.M., VLEK, P.L.G. and LINDSAY, W.L. 1984. Ammonia volatilization from urea phosphates in calcareous soils. Soil Sci. Soc. Am. J. 48:921-927.
- ELRASHIDI, M.A. and LINDSAY, W.L. 1984. Fluorine supplement to Technical Bulletin 134: Selection of standard free energies of formation for use in soil chemistry. Colo. Agric. Exp. Sta., Fort Collins, Colorado.

01.015 CRIS0096764 THE EFFECT OF ATMOSPHERIC DEPOSITION ON SOILS, PLANTS, AND WATERS

REUSS J O; WALTHALL P M; LINDSAY W L;
Agronomy; Colorado State University, Fort
Collins, COLORADO 80523.
Proj. No.: COLO0623 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 85 to 30 JUN 90

Objectives: To clarify the chemical processes that occur when soils are impacted by acid deposition, and the effects of these processes on the chemical composition of soil solutions and drainage waters. To evaluate the probability of deleterious effects occurring from current levels of deposition due to anthropogenic sources, the nature of such effects, their severity, and the time scale on which such effects are likely to be observed. To determine the probable effects of changes in current deposition levels, particularly acid deposition, on our soil, plant and water resources.

Approach: The general approach will involve a combination of theoretical studies using chemical models, and field and laboratory studies to evaluate the applicability of these models. Specific approach will include, but not be limited to, the following: 1. Development and testing of simple and accurate laboratory methods to determine input parameters required by current chemical models. 2. Field and laboratory testing of theoretical relationships utilized in chemical models. 3. Evaluation of cation replacement capacity of soil minerals. 4. Further model development, including refinement and expansion of current models and investigation of entirely different modelling

approaches.

01.016 CRIS0083194 ECONOMIC ANALYSIS OF NATURAL RESOURCE AND ENVIRONMENTAL ISSUES IN COLORADO

YOUNG R A; WALSH R G; HUSZAR P C; Economics;
Colorado State University, Fort Collins,
COLORADO 80523.
Proj. No.: COLO0328 Project Type: HATCH
Agency ID: CSRS Period: 08 AUG 80 to 30 SEP 83

Objectives: Objectives---The overall objective of the research is to study the demand, supply and economic value of Colorado Natural resources and environmental commodities, and to evaluate market and non-market allocative mechanisms for achieving maximum social return from the resources.

Approach: Analyze the value of water in withdrawal uses (agriculture, households, industries and non-withdrawal uses (recreation); Investigate the economic forces underlying conservation of rural lands to urban uses and evaluate alternative public policies for influencing land use and the extent of urban sprawl evaluate the demand for the management of outdoor recreation on public lands and waters. Evaluate the impact of growing demand for energy on Colorado's economy and environment. Study the economic impacts of natural hazards. Evaluated the economic benefits of air and water quality improvement. Formulate and test new methodologies for ascertaining the economic impacts (in allocative, distributive, and regional dimensions) of changes in the demand for non-marketed environmental goods and services.

Progress: 83/01 to 83/09. The overall objective of this research program is to study the demand, supply and economic aspects of Colorado's natural resources and environmental endowments, to evaluate market and non-market allocation mechanisms for achieving optimal social returns from natural resources, and to assist in conflict resolution via public policy analysis arising from competing uses of these resources. During this time period, research continued on water use allocations and quality aspects, groundwater use in agriculture, an updating of Colorado water case law, option demand for recreational uses, values of hunting and fishing in Colorado, some preliminary work on the grasslands plowout problem in eastern Colorado, and related natural resource economics issues. Due to reorganization of agricultural programs at CSU, a new Department of Agricultural and Natural Resource Economics was established in the College of Agricultural Sciences on July 1, 1983. As a result of this action, this project (Colo 328) is being terminated and will be replaced by a new reoriented research project, "Natural Resource Economics and Regional Resource Allocation Issues", effective October 1, 1983.

Publications: 83/01 to 83/09

DAVITT, G.U. and WALSH, R.G. 1983. A demand function for length of stay on ski trips to Aspen. *Journal of Travel Research*. 21(Spring).

MCKEAN, J.R. and WEBER, J.C. 1983. The economy of Lincoln, Sublette, Sweetwater and Uinta Counties, Wyoming, Rock Springs BLM District, Technical Report No. 40, Colorado Water Resources Research Institute, Colorado State University.

MCKEAN, J.R. and NOBE, K.C. 1983. 1981 Colorado sportsman survey: Direct and indirect effects of expenditures for hunting and fishing in Colorado (Contract Report for Colorado Division of Wildlife and Bureau of Land Management).

GILLIAM, L.D., MILLER, N.P. and WALSH, R.G. 1983. Congestion and willingness to pay for expansion of skiing capacity. *Land Economics* 59. (May 1983).

GILLIAM, R.A., LDOMIS, J.B. and WALSH, R.G. 1984. Valuing option, existence, and bequest demands for wilderness. *Land Economics* 60. (February 1984).

and NOAA, and a number of sites are supported by state agencies and private corporations. Since the beginning of the program in 1978, this monitoring network has expanded to 108 operating sites across the country, including Alaska and American Samoa. In 1983, NADP will become the core of the National Trends Network (NTN) which is being established under the mandated National Acid Precipitation Assessment Plan, with the addition of approximately 40 monitoring sites anticipated by 1984. Data published by the program now includes eight volumes covering data from July of 1978 through December of 1980. In addition, the monitoring data is available on computer tape either from the Natural Resource Ecology Laboratory, Colorado State University, or from the Environmental Protection Agency Data Management System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM. 1982. NADP Instruction Manual: Site Operation. Beigelow, D.S. (Editor). Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO. 30 pp.

01.017 CRIS0077142
ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURAL AND FORESTED LAND AND SURFACE WATERS

GIBSON J H; Natural & Environmental Res; Colorado State University, Fort Collins, COLORADO 80523.
 Proj. No.: C0L02014 Project Type: SPECIAL GRANT
 Agency ID: CSRS Period: 03 JUL 78 to 30 SEP 80

Objectives: Establish Atmospheric Deposition Network to determine spatial & temporal trends in supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter. Determine relative importance of precipitation & dry particulate matter. Develop optimum procedures. Determine stability of collection of precipitation constituents. Investigate transport & transformations. Organize & coordinate research in SAES, FS, & other institutions on the effects of atmospheric deposition on the productivity of agricultural crops, forests, range, wet lands, & surface waters.

Approach: Provide coordination for development of a program nationally to meet objectives including organization of central analytical laboratory & data analysis management service.

Progress: 82/01 to 82/12. Funds made available by the North Central Region of the State Agricultural Experiment Station (NC-141) and the U.S. Department of Agricultural CSRS are combined to support the coordination, data management and publications for the NC-141-sponsored program in atmospheric deposition referred to as the National Atmospheric Deposition Program (NADP). This support has been primarily directed to the establishment and coordination of a national atmospheric deposition monitoring network. Additional support has been obtained from other Federal agencies including BLM, EPA, USGS, USFS

01.018 CRIS0089822
CHEMISTRY OF ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

GIBSON J H; Natural Resource Ecology Lab; Colorado State University, Fort Collins, COLORADO 80523.
 Proj. No.: C0L00223 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife, and fish; c) the chemical composition of surface and ground waters; and d) atmospheric visibility and the corrosion of metals, masonry.

Approach: Provide coordination to further develop and maintain the National Atmospheric Deposition Program (NADP) chemical deposition network as well as the NAPAP National Trends Network (NTN).

Progress: 83/01 to 83/12. This project furnished administrative support for research carried on under the IR-7 interregional research project goals stated above.

Publications: 83/01 to 83/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.019 CRISO081176
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

GIBSON J H; Office of The Director; Colorado State University, Fort Collins, **COLORADO** 80523.

Proj. No.: COL00223 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish Atmospheric Deposition Network to determine spatial and temporal trends in supply of beneficial nutrient elements and potentially injurious substances in precipitation & dry particulate matter. Determine relative importance of precipitation & dry particulate matter. Develop optimum procedures. Determine stability of collection or precipitation constituents. Investigate transport & transformations. Organize and coordinate research in SAES, FS & other institutions on the effects of atmospheric deposition on the productivity of agricultural crops, forests, range, wet lands & surface waters.

Approach: A program coordinator's office will be maintained to provide support for the NC-141 regional research project including project coordination, travel, special analyses and other project activities as needed by the regional research project. (This is to cover the RRF Off-the-Top Trust Fund to NC-141).

Progress: 82/01 to 82/12. Funds made available by the North Central Region of the State Agricultural Experiment Station (NC-141) and the U.S. Department of Agricultural CSRS are combined to support the coordination, data management and publications for the NC-141-sponsored program in atmospheric deposition referred to as the National Atmospheric Deposition Program (NADP). This support has been primarily directed to the establishment and coordination of a national atmospheric deposition monitoring network. Additional support has been obtained from other Federal agencies including BLM, EPA, USGS, USFS and NOAA, and a number of sites are supported by state agencies and private corporations. Since the beginning of the program in 1978, this monitoring network has expanded to 108 operating sites across the country, including Alaska and American Samoa. In 1983, NADP will become the core of the National Trends Network (NTN) which is being established under the mandated National Acid Precipitation Assessment Plan, with the addition of approximately 40 monitoring sites anticipated by 1984. Data published by the program now includes eight volumes covering data from July of 1978 through December of 1980. In addition, the monitoring data is available on computer tape either from the National Resource Ecology Laboratory, Colorado State University, or from the Environmental Protection Agency Data Management System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.020 CRISO100004
ATMOSPHERIC DEPOSITION IN NATURAL ECOSYSTEMS OF THE WESTERN UNITED STATES

FOX D G; Rocky Mountain Forest and Range Experiment Station; Colorado State University, Fort Collins, **COLORADO** 80523.

Proj. No.: RM-2153 Project Type: INHOUSE
 Agency ID: FS Period: 01 OCT 84 to 30 SEP 89

Objectives: Create the basic knowledge needed to determine aquatic and terrestrial ecosystem effects resulting from specifically identified air pollution sources.

Approach: The research is sequentially structured to provide (1) protocols for quantifying physical and chemical environmental factors that influence aquatic and terrestrial ecosystems, (2) a better understanding of atmospheric delivery and ecosystem reception of air pollutants, and (3) knowledge of the biological effects caused by air pollutants introduced into ecosystems.

01.021 CRISO045287
EFFECT OF ENVIRONMENTAL AND AGRICULTURAL MANAGEMENT ON DENITRIFICATION AND SOIL/AIR N(2)O EXCHANGE

MOSIER A R; HUTCHINSON G L; Integrated Row Crop Mgmt Syst Southern Piedmont Conserva Lab; USDA Agricultural Research Service, Fort Collins, **COLORADO** 80521.

Proj. No.: 5402-20780-011-00D
 Project Type: INHOUSE
 Agency ID: ARS Period: 02 MAY 79 to 02 MAY 84

Objectives: Evaluate in field and laboratory studies the key physical, chemical and biological phenomena which influence denitrification as it relates to nitrogen fertilizer use efficiency and the aerodynamic exchange of N(2)O between soil and the atmosphere.

Approach: A soil cover method and micrometeorological techniques will be employed to measure N(2)O flux from field soils. Field sites will be selected where comprehensive studies can be conducted to determine what conditions promote denitrification and N(2)O release from or absorption by the soil. At these sites the effect on vertical N(2)O exchange of environmental variables such as season, temperature, soil type and agricultural management factors such as crop, fertilization and irrigation will be considered. Flux measurements will be made frequently throughout the cropping season as each management step is taken. Laboratory studies will be conducted to relate field observations to denitrification theory and to determine the relationship between N(2)O production and total denitrification.

Progress: 83/01 to 83/12. Field N measurements of N(2) and N(2)O emissions from N-fertilized cropped fields and a native shortgrass prairie have indicated that in both

systems little N loss occurred from denitrification. Data collected in 1983 tend to confirm these observations. A model which utilizes soil water, nitrate, ammonium and temperature data was developed to simulate N(2)O evolution from the shortgrass prairie. The model permits estimation of the individual contribution of nitrification and denitrification to N(2)O evolution. Acetylene, commonly used in denitrification work to block N(2)O reduction to N(2), was shown in laboratory studies to accelerate nitrate reduction. Acetylene was not directly utilized as a carbon source but the compound increased soil carbon metabolism thereby increasing the rate of denitrification

Publications: 83/01 to 83/12

- MDSIER, A.R., PARTON, W.J. and HUTCHINSON, G.L. 1983. Modelling nitrous oxide evolution from cropped and native soils. In R. Hallberg (ed.) Environmental Biogeochemistry Ecol. Bull. (Stockholm) 35:2129-2141.
- HAIDER, K., MDSIER, A.R., and HEINEMEYER, O. 1983. Side effects of acetylene on the conversion of nitrate in soil. Z. Pflanzenernahr. Rodenk. 146:222-233.
- HAIDER, K., MDSIER, A.R., and HEINEMEYER, O. 1983. Side effects of acetylene on denitrification in soil. Agronomy Abstr. p. 159.
- MDSIER, A.R. and PARTON, W.J. 1983. Denitrification in a shortgrass prairie: Modelling approach. 6th Int. Symp. on Environ. Biogeochem. p. 65. "Abstract"

01.022 CRIS0046570 REDOX POTENTIAL AND NITRIFICATION-DENITRIFICATION REACTIONS IN SOIL

GUENZEL W D; Southern Piedmont Conservation Lab; USDA Agricultural Research Service, Fort Collins, COLORADO 80521.
Proj. No.: 5402-20780-015-00D

Project Type: INH DUSE
Agency ID: ARS Period: 30 SEP 80 to 30 NOV 85

Objectives: Determine the rate of denitrification in soil as a function of redox potential. Determine effects of redox potential, pH and soil properties on reactions of amino sugars and identify gaseous nitrogen products.

Approach: Laboratory studies will involve a close examination of the many interacting factors involved in the formation and reduction of N(2)O and the reaction of amino sugars and associated compounds with mineral nitrogen sources. The main emphasis will be placed on the effect of Eh and pH on reaction rates and pathways and compound stability in the nitrification-denitrification sequence. Redox systems will be designed to control Eh and pH at any desired value and will incorporate either a flow through or sealed technique for gas introduction and analysis. When appropriate, N labeled compounds will be used. Available detection equipment includes a mass spectrometer (MS), gas chromatograph (GC) with an electron capture detector, and GC-MS.

Progress: 83/01 to 83/12. Redox potentials and soil temperatures were measured at several depths in a barley field in northeastern Colorado. During the entire growing season, the mean redox potentials at any depth were not low enough to expect the denitrification of nitrate to nitrous oxide, although a very few individual readings were in the low 300 mV (Eh) range. The majority of emitted N(2)O was detected after a heavy rain and snow storm in May and an irrigation in July. Most of the N(2)O loss probably resulted from the nitrification pathway. Rates of N(2)O production or utilization in controlled redox soil slurries showed that not only was redox potential an important factor in evaluating the process, but small amounts of oxygen, NO(3), and NO(2) also had a profound influence on rate reaction and the type of transformation.

Publications: 83/01 to 83/12

- BEARD, W.E. and GUENZEL, W.D. 1983. Volatile sulfur compounds from a redox-controlled-cattle-manure slurry. J. Environ. Qual. 12:113-116.

01.023 CRIS0085035 DEVELOPING FORESTS: EFFECTS ON SOIL AND WATER QUALITY

KRUG E C; FRINK C R; Soil & Water; Connecticut Agric Expt Sta, New Haven, CONNECTICUT 06504.
Proj. No.: CDNH00744 Project Type: HATCH
Agency ID: CSRS Period: 07 AUG 81 to 16 SEP 83

Objectives: Determine changes of five benchmark soils established in 1927 under developing Connecticut forests. Characterize soils from farm fields, developing and mature forests in the Bantam Lake watershed. Determine sediment characteristics and phosphorus in runoff from these soils. Determine ability of sediment to sorb or release phosphorus after deposition in Bantam Lake.

Approach: Determine physical, chemical and mineralogical properties of soils collected from long term forest plots and compare with analyses obtained 1927-1931. Analyze soils across the successional gradient in the Bantam Lake watershed. Measure phosphorus and suspended sediment in low order streams during low and high flow in the watershed. Incubate silt-sized samples from these watershed soils in sediments in Bantam Lake.

Progress: 83/01 to 83/09. Several small lakes in Connecticut have apparently become acidified according to a recent study of lakes in New England by the U.S. Fish and Wildlife Service. The most pronounced acidification was observed in Emmons Pond in Hartland, CT where the pH is now approximately 4.6. Preliminary investigations revealed that the pond was created by damming a former swamp. Most of the watershed was farmed at one time but now supports a mature stand of hemlock. Streams entering the lake pass through and are acidified by sphagnum peat moss. The specific mechanisms responsible for acidification will be examined more thoroughly in the coming year under Hatch 747.

Publications: 83/01 to 83/09

KRUG, E.C. and FRINK, C.R. 1983. Acid rain on acid soil: A New Perspective. Science 221:520-525.

KRUG, E.C. and FRINK, C.R. 1983. Effects of acid rain on soil and water. Conn. Agr. Exp. Sta. Bull 811. In Press.

01.024 CRIS0090172
EFFECTS OF MAN ON ACIDITY OF SOIL AND RUNOFF

KRUG E C; FRINK C R; Soil & Water; Connecticut Agric Expt Sta, New Haven, **CONNECTICUT** 06504.
 Proj. No.: CONH00747 Project Type: HATCH
 Agency ID: CSRS Period: 10 MAY 83 to 31 JUL 86

Objectives: Determine the effects of forest recovery on Connecticut soils; test the hypothesis of buffering by organic acids; determine causes of the acidification of a Connecticut lake.

Approach: Compare changes in soil with changes in forests, both in long-term forest plots and at sites to be sampled in cooperation with the US Forest Service; Extract organic soil horizons with solutions at different pH values and determine relative roles of ion exchanges and humus in buffering leachate; determine land use in watershed of Emmons Pond and compare with nearby watershed that are not acidified.

Progress: 84/01 to 84/12. Studies of three Connecticut watersheds were completed this year. Special attention was given to Emmons Pond which was part of the New England synoptic lake and stream survey and one of only eight waters in the region having historical data showing acidification to pH < 5. Chemical and watershed data were used to critically examine water chemistry models developed to estimate acidification by acid rain. Both the Henriksen model and historic pH data indicate that Emmons Pond has been acidified by 1.3 pH units. However, it is the growth and establishment of sphagnum mosses following disturbance and increased precipitation of the 70s that is the source of H⁺ to emerging groundwaters that feed the pond. Fundamental assumptions (commonly used in modeling acidification) that Ca and SO₄ are conservative and that Ca/Mg is constant need revision. Sphagnum preferentially removes Ca, altering Ca/Mg three-fold. Over 50% of SO₄ is mineral weathering. While water chemistry models gave reasonable estimates of acidification in this study they were found not to indicate the source of H⁺.

Publications: 84/01 to 84/12

KRUG, E.C. and ISAACSON, P.J. 1984. Influence of dilute acid treatments on organic and inorganic chemistry of leachate from organic-rich horizons of an acid forest soil. Soil Science 137:370-378.

KRUG, E.C. and FRINK, C.R. 1983. Effects of acid rain on soil and water. CT. Agric. Exp. Sta. Bull. 811. 45 pages.

KRUG, E.C. and FRINK, C.R. 1984. Letters: Acid rain and soil chemistry. SCIENCE 225:1428, 1433-1434.

01.025

CRIS0083303

IDENTIFICATION AND MOVEMENT OF ORGANIC CHEMICALS IN SOILS

SAWHNEY B L; FRINK C R; KOZLOSKI R; Soil & Water; Connecticut Agric Expt Sta, New Haven, **CONNECTICUT** 06504.

Proj. No.: CONH00742 Project Type: HATCH
 Agency ID: CSRS Period: 01 JAN 81 to 29 JUL 85

Objectives: Investigate the reactions and movement of organic chemicals in soils to provide safe disposal of organic pollutants. To improve the purge and trap method for the analysis of volatile organic compounds by GC and GC/MS.

Approach: Measure reaction and movement of organic chemicals in soil columns in the laboratory. Measure organic chemicals in leachates from landfills, industrial disposal sites, and agricultural fields. Develop predictive models for movement of chemicals. Study trap adsorbents, columns, and relative volatility. After volatility with acids, bases, redox and other reagents.

Progress: 85/01 to 85/07. Investigation of the movement of organic pollutants in the groundwater beneath a landfill in Granby, CT have been completed. Diethyl ether, methylethyl ketone, methylisobutyl ketone, benzene and toluene were the major pollutants identified. The plume was found to move from east to west as predicted from the general hydrology of the region. However, a number of borings revealed a north-south trough in the bedrock that bisects the landfill site. During low flow, leachate appeared to be caught in the trough and redirected into southerly flow. Capping the landfill site and diversion of storm water effected rapid decrease in the concentration of pollutants in monitoring wells at the site, but had little influence on bedrock wells to the south. Thus, local hydrologic features may be important in determining the exact pattern of movement of pollutants.

Publications: 85/01 to 85/07

SAWHNEY, B.L. 1985. Vapor-phase sorption and polymerization of phenols by smectite in air and nitrogen. Clay and Clay Min. 33(2):123-127.

SAWHNEY, B.L. and KOZLOSKI, R.P. 1985. Reply to "Comments on Organic Pollutants in Leachates from Landfill Sites." J. Environ. Qual. 14(1):157.

01.026

CRIS0089292

AN ASSESSMENT OF ACID RAIN ON LEACHING ELEMENTS FROM DELAWARE SOILS INTO GROUND WATER

SPARKS D L; Plant Science; University of Delaware, Newark, **DELAWARE** 19711.

Proj. No.: DELO0768(1) Project Type: STATE
 Agency ID: SAES Period: 01 OCT 81 to 30 SEP 82

Objectives: Characterize the cations which might be released into groundwater from soil systems under acid rain conditions; and determine the kinetics of ionic release, especially aluminum, into groundwater from soil

systems under acid rain conditions.

Approach: Three major soil types from Delaware and three pure clay minerals common in Delaware soils will be used in the study. The soils will be fully characterized as to their chemical, mineralogical, and physical properties. The effect of acid rain deposition on the kinetics of release of anions and cations will be investigated using miscible displacement technique. Soil profiles will be assembled in 100 cm long C-column systems, attached to a fraction collector and leached with simulated acid rain water of pH 5.6, 4.8, 3.4, and 2.5 at a flow velocity of 1.0 and min . The clays will be leached using a Nucleopore filter. Twenty ml of leachate will be collected every 20 minutes for at least 72 hours. The leachates will be analyzed for the macro and micro elements and for heavy metals. The kinetic data will be fitted to numerous theoretical equations.

01.027 CRIS0048807
**ECONOMIC IMPACTS OF ENERGY USE AND DEVELOPMENT
 ON AGRICULTURE AND NATURAL RESOURCES**

ANDERSON W D; GREEN J W; USDA Economic Research Service, Washington, **DISTRICT OF COLUMBIA** 20250.

Proj. No.: NRED-LUC&O-4727

Project Type: INHOUSE

Agency ID: ERS Period: 01 JAN 76 to 30 DEC 83

Objectives: Estimate economic and locational impacts of coal mining, transportation, and utilization upon agriculture, land, water, air, and natural resource systems.

Approach: Project levels and locational impacts of coal development for the United States. Assess the impact of the 1990 base case projection on agriculture, and on land, water, and air resources. Provide special analyses to the Universities Research Group on Energy (URGE) (funded by EPA) to help assess alternative strategies for reducing damage from coal development, especially from coal-related pollution.

Progress: 82/10 to 83/09. A draft report was prepared on the impacts of energy development on rural resources. The principal investigator was assigned to EPA for FY 83 to complete specific data and modeling assignments for that agency.

Publications: 82/10 to 83/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.028 CRIS0120146
INDUSTRIAL AND AGRICULTURAL POLLUTION IMPACTS

BARSE J; USDA Economic Research Service, Washington, **DISTRICT OF COLUMBIA** 20250.
 Proj. No.: NRED-EIRS-4798 Project Type: INHOUSE
 Agency ID: ERS Period: 01 OCT 83 to 30 SEP 86

Objectives: Calculate economic benefits to farmers, by region, and to consumers of alternative strategies to mitigate crop damage caused by gaseous air pollutants, principally ozone and sulfur dioxide.

Approach: Evaluate the degree of physical and economic damage to agricultural land and water, including groundwater, from toxic residuals, such as industrial chemical waste dumps.

Progress: 83/10 to 84/09. Literature in the physical and biological sciences and in economics on the impacts of air pollutants and acid rain on agriculture have been reviewed. An annotated bibliography, reflecting this review has been prepared and peer reviewed, and is to be published in FY 1985. Analytical work to project the economic impacts of ozone pollution on agricultural producers and consumers of farm products has started. The extent of groundwater pollution from toxic residuals, including those from pesticides and fertilizers as well as hazardous chemical wastes, is being evaluated. Planning is starting to analyze economic impacts upon rural areas once the extent of such pollution of groundwater is understood.

Publications: 83/10 to 84/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.029 CRIS0089958
**CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON
 AGRICULTURE, FORESTRY, SURFACE WATERS, AND
 MATERIALS**

RIEKERK H; GHOLZ H L; CANFIELD D E; Forest Resources & Conservatn; University of Florida, Gainesville, **FLORIDA** 32611.
 Proj. No.: FLA-FOR-02321 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America, (Network Research), and to assess the effects of atmospheric deposition on land productivity, animal productivity, and water quality (Effects Research).

Approach: Network Research. Wet/dry fall collection stations in Florida in association with weather stations of ongoing research programs directly benefitting from the atmospheric deposition data. Weekly collection and sample shipment with weather data to, and return of data and synthesis reports from NAOP central laboratory. Effects Research. Comparative importance of wet/dry fall on nutrient status of plants, soil and waters (Proj. Stat., A4). Effects wet/dry fall on forest nutrient cycling and forest tree growth (B1, 2). Influence on Al mobility and toxicity to fine tree rootss (B6).

Progress: 83/10 to 84/09. Atmospheric deposition was monitored weekly at the Bradford Forest weather station in north-central Florida from Jan 1978 through Aug 1984. Acidity data from the first five years showed a highly significant drop of 0.2 pH units per year down to pH 4.6. Data from the sixth year initially

followed the same trend but a reversal began after the summer of 1983 raising the average pH to about 5.0 during the summer of 1984. Plant nutrient inputs with rainfall during 1983 remained similar to that of the previous year and appeared to be significant for the longterm productivity of the sandy acid-leached pine flatwoods soils.

Publications: 83/10 to 84/09

RIEKERK, H. and KORHNAK, L.V. 1984. Environmental Effects of Silviculture in Pine Flatwoods. In 'Third Biennial Silvicultural Research Conference' Atlanta, GA, November 1984: (In press).

01.030 CRIS0086507
APPLICATION OF WATER QUALITY MODELS FOR AGRICULTURAL AND FORESTED WATERSHEDS

MANSELL R S; RAO P S C; Soil Science; University of Florida, Gainesville, **FLORIDA** 32611.
 Proj. No.: FLA-SOS-02112 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Modify, develop, and/or adapt process models of water, sediment and chemical transport for surface and subsurface flow.

Approach: Mechanistic transport models will be developed to describe subsurface movement of water and solutes through sandy soil occurring on small land areas having relatively homogeneous vegetative cover, topography and profile characteristics. One-dimensional numerical models will be used where the depth to the groundwater table is great and two-dimensional numerical models will be used for tuber- or ditch-drained soils with a water table located at shallow depth. Adsorption-desorption, microbiological transformation, and plant uptake sink terms will be included in certain of the models. The models will be verified and validated using water quality data for soil solution, groundwater, and drainage water from small experimental land areas.

Progress: 83/10 to 84/09. A chromatographic model as developed for the purpose of simulating multi-species leaching of cations in aggregated soil during infiltration with "acid rain". Instantaneous ion exchange was assumed to occur between ions in sorbed and solution phases. The soil solution was divided into mobile and immobile (stagnant) regions, with ion occurring in both regions. Ions in the mobile solution were assumed to undergo exchange with readily-accessible sites in the soil matrix, whereas ions in the immobile solution undergo exchange with slowly-accessible sites. A rate transfer of individual cations between the mobile and immobile regions provides a kinetic characteristic for ion absorption by exchange sites located in regions of immobile solution. The model was solved for binary and tertiary exchange systems with mono and hetero-valent ions. Steady soil water flow conditions were assumed. A sensitivity analysis of model parameters was performed.

Publications: 83/10 to 84/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.031 CRIS0089826
CHEMISTRY OF ATMOSPHERIC DEPOSITION -- EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

RHUE R D; MANSELL R S; Soil Science; University of Florida, Gainesville, **FLORIDA** 32611.
 Proj. No.: FLA-SOS-02321 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Objectives: To assess the effects of atmospheric deposition on the productivity of crops, forest trees, and soils.

Approach: In a field and laboratory study, simulated acid rain at various pH's will be applied to soils. An established field plot site on a Typic Quartzipsamment soil near Lake McCloud in North Central Florida will continue to be irrigated with acid rain (70:30 mixture of H₂SO₄:HNO₃) adjusted to pH 3.0, 3.7, and 4.7 (control). Porous glass suction tube lysimeters installed at 15-75 cm. soil depths will be used to collect soil solutions for analyses of various elements and pH. Pine seedlings will be planted in selected plots and irrigated with control and acid rain. An A1 treatment will be superimposed on several acid rain plots.

Progress: 83/10 to 84/09. A multicomponent chromatography model has been used to describe cation leaching in soil columns treated with acid solution. In the model, soil water was divided into mobile and immobile region, with ion exchange assumed to occur instantaneously in the region contacting the mobile water. A rate-limited transfer of cations between mobile and immobile regions was included in the model and resulted in delayed ion exchange reactions at surfaces contacting the immobile water. The model has been solved for binary and tertiary exchange systems with mono- and heterovalent ions. The model predicts breakthrough curves which are in qualitative agreement with results from cation leaching studies using soil columns. The extent to which experimental breakthrough curves can be simulated by the model depends on the use of appropriate measured values for cation selectivity coefficients for a given soil. Effects are currently underway to evaluate the validity of certain assumptions used in developing the model. These include the assumptions of constant cation exchange capacity, that H⁺ ions are removed from solution only by ion exchange reactions, and that local equilibrium exists with respect to all ion exchange reactions.

Publications: 83/10 to 84/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.032 CRIS0083289
**EFFECTS OF ACID PRECIPITATION ON SELECTED SOILS
 OF THE SOUTHEASTERN UNITED STATES**

VOLK B G; GRAETZ D A; BITTON G; Soil Science;
 University of Florida, Gainesville, **FLORIDA**
 32611.
 Proj. No.: FLA-SOS-02058 Project Type: STATE
 Agency ID: SAES Period: 01 SEP 80 to 31 DEC 82

Objectives: To examine the affects of acid precipitation on the chemical properties of soils, including changes in soil nutrient supply and release of potentially toxic substances. To determine the relationship between organic matter decomposition and acidification. To determine the effects of acid rainfall on nitrogen transformations in soils, including N(2) fixation, mineralization, nitrification and denitrification and to assess the impact of acidification on soil microbial populations.

Approach: Acid rain, pH 3.7, will be applied on transects of a sandhill watershed site with typic quartzipsamments soils. Change in soil microbiology, chemistry, and concentrations of elements in percolation water will be monitored. Latobratoy soil columns using soils from various locations will be monitored for changes caused by acid rain leaching.

Progress: 83/01 to 83/12. Investigations using artificially acidified irrigation water (70:30, H(2)SO(4):HNO(3)) at pH 3.0, 3.7 and 4.7 over a two year period at a lake site in north central Florida suggest a relatively high and rapid loss of nutrients from the soil surface to the water table 4 m below. Considering the low CEC (3.5 me/100 g), the low base saturation (4%) and the high hydraulic conductivity (74 cm/hr) at this site, the implication with respect to the rooting zone of natural vegetation is clear. The magnitude of leaching also depends on the nature of the ion, the depth being considered and the degree of acid treatment. Readsorption of ions in the soil profile was shown to occur, which further complicates overall assessment of the real effect of acid rain. Most of the applied water, regardless of amount, is lost from the soil site to the water table within 48 hours. Lateral movement of the groundwater to the lake likewise was very fast, due to the high hydraulic conductivity. There was essentially little non-veritcal flow to the water table, and horizontal wave movement towards the lake was rapid, despite the essentially flat water table extending more than 50 meters from the lake. The effect of the acid treatments from a very large rain event could be observed in the groundwater near the lake within 24 hours.

Publications: 83/01 to 83/12

- VOLK, B.G., BYERS, G.E., BITTON, G. 1983. Effects of acid precipitation on a typic quartzipsamment soil in Florida, USEPA National Acid Precipitation Assessment Program Effects Research Review Summaries. Feb. 21-25, 1983.
 VOLK, B.G., and BYERS, G.E. 1983. Effects of acid precipitation on a typic quartzipsamment soil in Florida. In Acid Deposition: Causes and Effects, Eds. A.E.S.

Green and W.H. Smith, Government Industries, Sept. 1983. p. 265-282.
 BITTON, G., VOLK, B.G., BYERS, G.E. 1983. Effects of acid precipitation on microbiological and chemical parameters in soil. Developments in Acid Zone Ecology and Environmental quality. VIII.

01.033 CRIS0084233
**NITROGEN MANAGEMENT FOR GRAIN CROPS ON MEDIUM
 ACID SOILS**

GOODROAD L L; Agronomy; Georgia Agric Expt Station, Experiment, **GEORGIA** 30212.
 Proj. No.: GED01305 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 81 to 30 JUN 86

Objectives: To evaluate precisely defined N rates from various sources, for maximizing feed-grain production under acid versus mildly acid soil stress conditions; to compare N efficiency among genotypes (hybrids); study the feasibility of utilizing nitrification inhibitors and controlled release materials to maximize N use efficiency; and evaluate the contribution of residual soil N for production in cropping sequences.

Approach: In order to assess treatment effects under natural environments, field plots will be utilized to attain the objectives of the study. Nitrogen balances will be attempted by soil N determinations, crop utilization, soil residues and N losses. Narrow increments of N from selected sources will be evaluated for efficient feed grain production at selected soil pH levels. Selected tolerant genotypes which have been developed for acid soil stress conditions will be compared for N use efficiency based on production levels, N uptake and protein levels. Nitrogen sources, with and without nitrification inhibitors, will be evaluated for selected species. Selected sites will be evaluated for residual N contributions to production of subsequent crops. Long-term rotations, including legumes such as soybeans, will be evaluated for N efficiency.

Progress: 84/01 to 84/12. Nitrogen rate and time of application studies have been established for winter wheat, sorghum, fescue and ratoon sorghum. Initial results indicate that double-cropped winter wheat (cv. Stacy) yields increased with N rates to 100 kg/ha following soybeans. An additional 30 kg N/ha at following (130 kg N/ha total) produced the highest yields for wheat following sorghum. In 1984, there was no increase in yields from split application of N at the 100 kg N/ha rate. Early growth of Triumph fescue was increased by N fertilizer compared to Kentucky 31 fescue. Studies in coastal plain soils have identified sulfur deficiencies which limit yields of winter wheat in sandy soils and soils with only shallow tillage. Seven corn hybrids commercially available in the southeastern U. S. were grown in field plots at three soil pH levels (4.8, 5.5, and 6.6) and four nitrogen (N) fertilizer rates (0, 80, 160, and 320 kg N/ha). Nitrogen efficiency parameters, grain yield/N supply (YE), total N uptake/N supply (UP), grain yield/total N uptake (UE), and

grain yield/N uptake after silking (TE), were calculated. Grain yields were highest at the 160 kg N/ha rate, and there was a significant interaction between pH and variety effects on grain yields. The treatments having significant effects on N efficiency parameters included N supply on YE; N supply, variety, and variety x N supply on UP; and N supply and variety on UE.

Publications: 84/01 to 84/12

- GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide production in aerobic soils and under varying pH temperature and water content. *Soil Biol. and Biochem.* 16:39-43.
- GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide emissions from soils during thawing. *Can. J. Soil Sci.* 64: 187-194.
- GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide emissions from forest, marsh and prairie ecosystems. *J. Envir. Qual.* 13:448-452.
- GOODROAD, L.L., KEENEY, D.R., and PETERSON, L.A. 1984. Nitrous oxide emissions from agricultural soils in Wisconsin. *J. Envir. Qual.* 13:557-561.

01.034 CRIS0074176
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE-WATERS

WALKER J T; Plant Pathology; Georgia Agric Expt Station, Experiment, **GEORGIA** 30212.
 Proj. No.: GE001249 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 JAN 83

Objectives: Establishing an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Determining the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to the total atmospheric deposition in various states and regions in the United States. Organizing research in the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters; etc.

Approach: Establish a collector of the wet/dry type (Volchok and Graveson) at an approved collection site and ship samples on scheduled basis to a central analytical laboratory for analysis. Determine the contribution and importance of these depositions to the state and region in terms of agricultural productivity (Agronomic crops) and effects on vegetation (trees, shrubs, or turf) in the rural and urban environments, specifically in terms of diseases and contribution to minor element requirements.

Progress: 77/12 to 83/01. Using the protocol of the NADP guidelines, an Aerochem Metric Precipitation Collector (Model 201) was installed in the Georgia piedmont in October, 1978. A recording rain gauge, wind vane-anemometer, and particulate sampler was

operated at the site. Ozone levels were monitored elsewhere. Precipitation samples were analyzed by the Central Analytical Laboratory. Particulates (TSP) were determined on a filter exposed for 24 h every 6 days. The effects of acidified water on a variety of plants under growth chamber, greenhouse, and field conditions were determined. The effect of aqueous solutions at different pHs on subsequent seed germination was studied. Over the 1979-81 period, the highest ionic constituent in rain was sulfate with an average of 2.6-3.5 mg/1/yr. followed by nitrate with 1.0 to 1.3 mg./1. The 3-yr. average for 9 ions in mg/1, was: Ca 0.24, Mg 0.13, K 0.18, Na 0.45, NH(4) 0.33, NO(3) 1.2, Cl 0.46, SO(4) 2.99, PO(4) 0.06. The lowest average pH occurred in the 2nd and 3rd calendar quarter, with values ranging from a low of 4.12 to high of 4.96. Average TSPs for 1979, 1980, and 1981, were 37.2, 38.7, and 46.7 mg./m³, respectively. Ozone averaged 3.6 pphm. Lead averaged .052 to .073 mg./m³ annually. Some plant species and cvs were injured by acidic mists at pH 1.8, but few plants were affected by pH 2.6 sprays. Grass seed germination was decreased by pH 2.6 solutions, but alfalfa, corn and cucumber were unaffected. Germination of some soybean cvs was reduced at pH 2.6.

Publications: 77/12 to 83/01
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.035 CRIS0089156
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATER, AND MATERIALS

WALKER J T; Plant Pathology; Georgia Agric Expt Station, Experiment, **GEORGIA** 30212.
 Proj. No.: GE001341 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish, the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings and other materials in machinery or structure.

Approach: The Georgia collection site has been operational since October, 1978, and will continue as part of the NADP program. Data obtained is available to all interested scientists. Efforts research on agricultural and horticultural crops will encompass general growth responses including biomass and yield from simulated rain treatments and symptomology. Influence of simulants on endemic pathogens of commercial crops will be determined in growth chambers and field plots. Cooperative studies with scientists in other departments and agencies will be initiated.

Progress: 84/01 to 84/12. The 1983 quarterly volume weighted average pH of rain falling at the Georgia NADP/NTN site was 4.37, 4.71, 4.57 and 4.57. The six month average for 1984 is 4.50. The 1983 rainfall was 112.35 cm; for the first six months of 1984 it is 49.75 cm. Sulfate and nitrate remain the principle rainfall constituents, with deposition rates in 1984 comparable to those in 1983; six month sulfate rates were 878.6 and 823.3, respectively. Nitrate (NO₃(S)) rates were 467.7 and 453.2. Total suspended particulates (ug TSP/M-3) averaged 23.7 for 1983, and 35.8 for nine months of 1984. Lead levels assayed on hi-vol filters remain low (0.03 mg/m³). Daily O₃(3) concentrations averaged 2.86 for May through October. A portable rain simulator, using Bete Simulated Rain Nozzles and PVC pipe, was constructed. Trials revealed that the 2.5 cm pipe with pumping system at 5 or 10 psi delivered 2.1 gals per minute to adequately wet soybean foliage. This deposition rate approximates 0.64 cm/h. To evaluate the system, Davis soybeans were planted on June 18 in a field previously fertilized with 2173 kg. of 5-10-15 per hectare. Lasso was applied after planting and the field irrigated on June 19 to enhance germination. Simulated rain (pH 3.5) was applied to soybeans in each of three 2.4m x 2.4m plots at 2 rates, 208 or 416 liters, on four dates from August 21 to September 28. Plants in each plot were counted and bean yield determined at maturity. No visible injury was detected on soybean foliage.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

01.036 CRIS0095963
ACID PRECIPITATION, AIR POLLUTANTS, AND THE GROWTH OF FOREST TREES ON THE SHAWNEE NATIONAL FOREST

WEAVER G T; MYERS C C; IVERSON L; Forestry; Southern Illinois University, Carbondale, ILLINOIS 62901.
Proj. No.: ILLZ-85-R-001 Project Type: STATE
Agency ID: OCI Period: 01 JUL 85 to 30 JUN 88

Objectives: To determine long-term growth patterns of trees on acid susceptible and non-susceptible forested soils; to statistically segregate confounding biotic and abiotic influences to isolate the likely contribution of acid deposition and other air pollutants to growth decline; measure chemical constituents of selected woody tissue to determine if chemical uptake is correlated with growth analysis and atmospheric deposition patterns.

Approach: Periodic increment of pines and oaks growing on plots with sensitive and non-sensitive soils will be determined by increment cores and stem analysis. Twenty-five 0.04 ha plots for each tree-soil combinations (total 100 plots) will be sampled. Growth data will be corrected for age and correlated with measured soil conditions, pH, CEC, and exchangeable cations. Increment cores will be analyzed for changes in contents of several pollutant-related metals.

01.037 CRIS0075198
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

GILMORE A R; Forestry; University of Illinois, Urbana, ILLINOIS 61801.
Proj. No.: ILLU-55-0303 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States.

Approach: Establish collection sites to give accurate and representative information, collectors will be of the wet/dry deposition type and dichotomous air-infiltration samplers. Analysis will be made on each sample: SO₄(4), NO₃(3), PO₄(4) ge of elements continues to be evaluated. At the DSAC location NO₃-(3) and NH₄+(4) show the highest concentration on the average. The most significant input of these ions occurs during the spring and summer. Calcium, sodium, magnesium and potassium are deposited in lower concentration and generally in that order of importance. Monitoring continues at all locations.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

01.038 CRIS0030313
MINERAL NUTRITION OF FOREST TREES

MCREE W W; Agronomy; Purdue University, West Lafayette, INDIANA 47907.
Proj. No.: IND050045 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 68 to 30 SEP 86

Objectives: Quantify the uptake rates interactions of plant nutrients by tree seedlings. Determine the influence of the root environment and physiological condition on nutrient absorption. Determine foliar nutrient levels useful in diagnosing nutrient shortages in trees. Examine the influence of atmospheric deposition of acids, metals and other materials on release on nutrients by soil weathering. Determine effects of material handling and amendments on tree rooting pattern in reconstructed soils on mineland.

Approach: Utilizing carefully controlled conditions the uptake parameters will be determined for tree species and compared to knowledge available on crops. The applicability of parameters and models developed for crops will be determined for forest trees. Foliar diagnosis and root development will be field oriented and make use of studies established in other projects. Atmospheric deposition will be simulated under laboratory conditions. Rooting studies on reclaimed soils will be adjunct to projects with outside funding.

Progress: 84/01 to 84/12. A study of the nutrient supply in native soils that have become acidified due to acid, mine drainage and/or an overburden of mine refuse was

initiated. Soils were collected from a site in Warrick Co. for analyses and the establishment of a greenhouse experiment. The influence of acidic deposition on the nutrient supply of soils at high elevation was initiated. Samples were collected and analyses began on 48 samples from 2 sites in the Mt. Zirkel Wilderness area of Colorado.

Publications: 84/01 to 84/12

MEYERS, L.L. and MCFEE, W.W. 1984. Manganese transformation in southern Indiana coal mine overburden. *Agronomy Abstracts*. p. 31.

01.039 CRISO075841
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

MCFEE W W; PAW-U K T; Agronomy; Purdue University, West Lafayette, **INDIANA** 47907.
 Proj. No.: IND050045-A Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 82

Objectives: Determine spatial and temporal trends in supply of beneficial and injurious substances in precipitation and dry particulate matter deposited in various regions of the US. Determine contribution of precipitation, dry particulate matter, aerosols, and gases to atmospheric deposition in various regions in the US. Develop optimum procedures for collecting precipitation and dry particulate matter. Determine effects of atmospheric deposition on productivity and host-parasite relationships of crops and forests.

Approach: Samples of precipitation and dry particulate matter will be collected weekly and analyzed for S(4), NO(3), PO(4), C1, NH(4), K, Na, Ca, Mg, pH, total and free acidity, and electrical conductivity. Measurements will be made of the input of nutrients from the atmosphere to various crops and toxic effects of precipitation constituents on crop plants and forest trees.

Progress: 82/01 to 82/12. Equipment to collect atmospheric deposition was installed at the Agronomy Farm, West Lafayette, IN, and became operational in July. Additional equipment is on hand for establishment of a station in southern Indiana. Wet deposition measured in weekly samples in the period, July-September 1982, had a mean pH of 4.1-4.2 at the West Lafayette location. This monitoring will continue as a part of Interregional Project, IR-7. A critical review of the literature on effects of acidic deposition of soils is being prepared for inclusion in a document for EPA.

Publications: 82/01 to 82/12

MCFEE, W.W. and CRONAN, C.S. 1982. The Action of Wet and Dry Deposition Components of Acid Precipitation on Litter and Soil. In: D'Itri (ed.). *Effects of Acid Precipitation on Ecological Systems*. Ann Arbor Science, Ann Arbor, MI.

MCFEE, W.W. 1982. Sensitivity Ratings of Soils to Acid Deposition: A Review. In Arthur, M.F., and Wagner, C.K. *Response of Agricultural Soils to Acid Deposition*.

Electric Power Research Institute, EA 2508, Palo Alto, CA.

GLASS, N.R. ARNOLD, D.E., GALLOWAY, J.N., HENDREY, G.R., LEET, J.J., MCFEE, W.W., NORTON, S.A., POWERS, C.F., RAMBO, D.L. and SCHOFIELD, C.L. 1982. Effects of Acid Precipitation. *Environ. Sci. Technol.* 16:162A-169A.

01.040 CRISO089884
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

MCFEE W W; PAW-U K T; Agronomy; Purdue University, West Lafayette, **INDIANA** 47907.
 Proj. No.: IND050045A Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, rangelands, wetlands and soils.

Approach: We will continue to operate one site at the Agronomy Farm to measure atmospheric deposition and plan to initiate a site in southern Indiana. We will develop and test models of the short and intermediate range transport of atmospheric, point source pollutants. Laboratory experiments on the effects of acidic deposition on the chemical and physical properties of soil will be used to examine the movement of metal in response to acidity and to evaluate soil sensitivity rating systems.

Progress: 84/01 to 84/12. Data from 2 years of studying the atmospheric deposition of acidic and nutrient materials in the precipitation at the Purdue Agronomy Farm were summarized and prepared for publication. The mean volume-weighted pH based on laboratory analyses is 4.36. The unweighted mean weekly sample pH based on measurements taken before shipment of the samples is 4.15. There is a tendency for sulfate and H ion concentration to be higher in the growing season. The mean annual S and N deposition in the precipitation based on two year's data is 8.4 kg/ha and 6.2 kg/ha respectively. Sampling and analysis of the precipitation of the Southwest Purdue Agricultural Center at Vincennes was begun in August, 1984 to support the studies of air pollution effects on melons being conducted there.

Publications: 84/01 to 84/12

MCFEE, W.W., ADAMS, F., CRONAN, C.S., FIRESTONE, M.K., FOY, C.D., HARTE, R.D. and JOHNSON, D.W. 1984. The acidic deposition phenomenon and its effects: Chapter E2, Effects on soil systems. EPA-600/8-83-016 F. pp. 2-1 through 2-57.

01.041 CRIS0068090
**NITROGEN AND SULFUR TRANSFORMATIONS IN SOILS
 RELATED TO FERTILIZER AND POLLUTION PROBLEMS**

BREMNER J M; Agronomy; Iowa State University,
 Ames, IOWA 50011.
 Proj. No.: IOW02096 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 75 to 30 SEP 83

Objectives: Obtain detailed information concerning nitrogen and sulfur transformations in soils related to fertilizer and pollution problems.

Approach: Processes responsible for volatilization of nitrogen and sulfur from soils, and factors affecting these processes, will be studied. The processes investigated will include denitrification, chemodenitrification, urea hydrolysis, sulfate reduction, and biodegradation of organic sulfur compounds. Methods of controlling nitrification, urea hydrolysis, and other nitrogen transformation processes in soils that affect crop utilization of nitrogen and contribute to air and water pollution problems will be evaluated, and factors influencing the effectiveness of nitrification and urease inhibitors will be determined. The fate of urease added to soils will be studied, and factors affecting urease activity and urease levels in soils and sorption of urea by soils will be investigated. The ability of soils to sorb sulfur and nitrogen gases identified as atmospheric pollutants, including NO, NO(2), SO(2), and H(2)S, will be studied, and the potential value of soils for purification of air polluted by these gases will be assessed.

Progress: 83/11 to 83/12. No progress report this period.

Publications: 83/11 to 83/12

MARTENS, D.A. 1983. Effectiveness of phosphoroamides for retardation of urea hydrolysis in soils. M.S. Thesis, Iowa State Univ., Ames. 40 p.

01.042 CRIS0091732
NITROGEN TRANSFORMATIONS IN SOILS

BREMNER J M; Agronomy; Iowa State University,
 Ames, IOWA 50011.
 Proj. No.: IOW02655 Project Type: HATCH
 Agency ID: CSRS Period: 04 OCT 83 to 30 SEP 88

Objectives: To obtain detailed information concerning nitrogen transformations in soils related to fertilizer and pollution problems and to find methods of controlling these transformations.

Approach: Processes responsible for volatilization of nitrogen from soils and factors affecting these processes will be studied. The processes investigated will include nitrification, denitrification, chemodenitrification, and urea hydrolysis. Methods of controlling nitrification, urea hydrolysis, and other nitrogen transformation processes in soils that affect crop utilization of nitrogen and contribute to air and water

pollution problems will be evaluated, and factors influencing the effectiveness of nitrification and urease inhibitors will be determined. The potential value of various compounds for inhibition of nitrification and urease activity in soils will be explored, and attempts will be made to develop improved techniques for research on denitrification and other nitrogen transformations in soils and for assessment of the availability of soil nitrogen to plants.

Progress: 84/01 to 84/12. Studies of the effects of seven insecticides (lindane, fenitrothion, fonofos, malathion, phorate, terbufos and carbofuran) and six fungicides (mancozeb, maneb, thiram, benomyl, captan, and terrazole) on denitrification of nitrate in soils showed that none of the compounds studied had a significant effect on denitrification when applied at the rate of 10 mu g g soil and that most of them either had no appreciable effect on denitrification, or enhanced denitrification, when applied at the rate of 50 mu g g soil. Reports that maneb, thiram, and terrazole inhibit denitrification in soil could not be confirmed. Evaluation of a flat-surface combination electrode for measurement of soil pH showed that it permitted direct, nondestructive measurement of the pH of soils at natural water levels and had the additional advantages of being durable, inexpensive, and easily cleaned. Studies of the effects of nine phenolic acids on seed germination and early plant growth in soils did not support the hypothesis that the adverse effect of plant residues on crop yields is due to phenolic acids derived from plant residues. Studies of the effects of 13 widely used fungicides on transformations of urea nitrogen in soils showed that, when applied at the rate of 1 mu g g soil, only maneb significantly inhibited urea hydrolysis in the three soils studied and only terrazole significantly inhibited nitrification of urea N in these soils.

Publications: 84/01 to 84/12

BREMNER, J.M. and BREITENBECK, G.A. 1984. Use of a flat-surface combination pH electrode for measurement of soil pH. Commun. Soil Sci. Plant Anal. 15:87-98.
 MARTENS, D.A. and BREMNER, J.M. 1984. Effects of fungicides on transformations of urea nitrogen in soil. Agron. Abstr. p. 189.
 BREMNER, J.M. and KROGMEIER, M.J. 1984. Effects of phenolic acids on seed germination and early plant growth in soil. Agron. Abstr. p. 183.

01.043 CRIS0092520
GAINS, LOSSES AND MANAGEMENT OF SOIL NITROGEN

BREMNER J M; Agronomy; Iowa State University,
 Ames, IOWA 50011.
 Proj. No.: IOW02672 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To assess the magnitude of and determine factors affecting losses and gains of soil nitrogen.

Approach: Processes responsible for volatilization of nitrogen from soils and factors affecting these processes will be studied. The processes investigated will include nitrification, denitrification, chemodenitrification, and urea hydrolysis. Methods of controlling nitrification, urea hydrolysis, and other nitrogen transformation processes in soils that affect crop utilization of nitrogen and contribute to air and water pollution problems will be evaluated, and factors influencing the effectiveness of nitrification and urea inhibitors will be determined. SOILS.

Progress: 84/01 to 84/12. Studies of the effects of 16 monosubstituted acetylenes (HC:CR) and 8 disubstituted acetylenes (RC:CR') on nitrification in soils showed that most of the compounds tested inhibited nitrification of ammonium by soil microorganisms and that some were potent inhibitors of nitrification. Phenylacetylene, 3-butyne-2-one and 1-phenyl-2-propyne-1-ol had the greatest inhibitory effect on nitrification, and acetylene monocarboxylic acid, acetylene dicarboxylic acid and 2-butyne-1-ol had the least effect. A comparison of the effects of phenylacetylene, N-Serve, and Dwell on nitrification in soils suggested that phenylacetylene may have practical value as a soil nitrification inhibitor. Research to account for the exceptionally large emissions of N_2O induced by fertilization of soils with anhydrous ammonia showed that the emission of N_2O from soil treated with N fertilizers is related to the fertilizer-induced change in soil pH and indicated that the large emissions of N_2O induced by anhydrous ammonia are due to the highly alkaline conditions within the fertilizer band resulting from the customary method of applying this fertilizer.

Publications: 84/01 to 84/12

- MARTENS, D.A., and BREMNER, J.M. 1984. Effectiveness of phosphoramides for retardation of urea hydrolysis in soils. *Soil Sci. Soc. Am. J.* 48:302-305.
- MCCARTY, G.W., and BREMNER, J.M. 1984. Inhibition of nitrification in soils by acetylenic compounds. *Agron. Abstr.* p. 189.
- BREITENBECK, G.A., and BREMNER, J.M. 1984. Effect of fertilizer-induced change in soil pH on emission of N_2O from soil treated with N fertilizers. *Agron. Abstr.* p. 183.
- MARTENS, D.A., and BREMNER, J.M. 1984. Factors influencing the effectiveness of phenylphosphorodiamidate for retardation of urea hydrolysis in soils. *Soil Biol. Biochem.* (In press).

Objectives: Establish an atmospheric deposition network. Determine the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to total deposition. Develop optimum procedures for collecting precipitation and dry particulate matter. Determine the stability of certain constituents of precipitation during collection, transport and storage prior to analysis. Investigate the transport and transformations of atmospheric constituents.

Approach: A network of precipitation collection sites will be established in the U.S. one of these sites will be in Central Iowa. Samples of precipitation and dry particulate matter will be collected at each site. The samples will be analyzed for SO_4^{2-} , NO_3^- , PO_4^{3-} , Cl, NH_4^+ , K, Na, Ca, Mg, pH, total and free acidity or alkalinity, and electrical conductivity. As the program develops, the analyses for heavy metals will be included.

Progress: 81/01 to 81/12. Rainfall collectors and measuring gauges were installed in 1978 at seven sites in Iowa. The sites are in Ames, the Agronomy farm in Boone County, Atlantic, Fairfax, Sigourney, Storm Lake, and Tripoli. Precipitation samples were collected on an event basis each year from May through November and analyzed for pH, conductivity, F, C, NH_4^+ , NO_3^- , SO_4^{2-} , PO_4^{3-} , K, M, Na, Ca, and Mg. With exception of a few samples each year, the pH of the precipitation samples analyzed from the seven sites ranged from 5 to greater than or equal to 7, with the majority of the samples having pH value near 6. The most recent results (for 1983) showed that the pH values ranged from 4.1 of one sample collected at the Agronomy farm 7.4 of a sample from Storm Lake. The means and standard deviations of the pH values at the seven sites were: Ames, 5.9 +/- 0.5; Agronomy farm, 5.9 +/- 0.7; Atlantic, 6.7 +/- 0.2; Fairfax, 6.2 +/- 0.7; Sigourney, 6.7 +/- 0.3; Storm Lake, 6.2 +/- 0.5; Tripoli, 6.5 +/- 0.3. Expressed in $\mu g/ml$, the mean values of NO_3^- -N and SO_4^{2-} -S, respectively, were 0.5 and 1.0 (Ames), 0.4 and 0.9 (Agronomy farm), 0.7 and 1.4 (Atlantic), 0.8 and 2.3 (Fairfax), 1.4 and 2.5 (Sigourney), 0.7 and 1.0 (Storm Lake), and 0.5 and 1.3 (Tripoli). In general, the means of NH_4^+ -N concentrations were equal or slightly greater than those of NO_3^- -N.

Publications: 81/01 to 81/12

- TABATABAI, M.A. 1982. Nutrient deposition by precipitation. *Proceedings of a Public Conference.* 120-140. Carroll University, University Heights, Cleveland, Ohio.
- TABATABAI, M.A. 1983. Atmospheric deposition of nutrients and pesticides. In F.W. Schaller and G.W. Bailey (eds.). *Proceedings of the National Conference on Agricultural Management and Water Quality*, pp. 92-108.
- SALEEM, H.B. 1983. Effect of pH on nitrogen mineralization and nitrification in soils. M.S. Thesis, Iowa State University, Ames. 110 p.
- TABATABAI, M.A. 1984. Effect of acid rain on soils. *CRC Crit. Rev. Environ. Cont.* (In press).

01.044 CRIS0074636
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION &
EFFECTS ON AGRICULTURAL & FORESTED LAND &
SURFACE WATER

TABATABAI M A; Agronomy; Iowa State University, Ames, IOWA 50011.
Proj. No.: IOW02276 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

LINZON, S.N., and TABATABAI, M.A. 1984.
Soil-air pollutant interaction. In S.V.
Krupa and A.H. Legge (eds.). Proceedings of
the International Conference on Air
Pollutants and Their Effects on Terrestrial
Ecosystem. Wiley

01.045

CRIS0089151

**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS**

TABATABAI M A; Agronomy; Iowa State
University, Ames, IOWA 50011.
Proj. No.: IOWO2601 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize
biologically important geographical and
temporal trends in the chemical climate of
North America. Assess the effects of
atmospheric deposition on the following: The
productivity of agricultural crops, forest
trees, rangelands, wetlands and soils; the
health and productivity of domestic food
animals, wildlife, and fish; the chemical
composition of surface and ground waters; and
atmospheric visibility and the corrosion of
metals, masonry and stone, paints and other
protective coatings, and other materials in
machinery or structure.

Approach: We have seven precipitation sampling
sites in operation in Iowa. Precipitation
samples will be collected on event basis at
these sites. The samples will be analyzed for
pH, conductivity, NH (4), NO (3), Cl , F .
SO (4), PO (4), K , Na , Ca , and Mg . The
annual amounts of H and each of the nutrient
elements added per unit surface area will be
calculated. Contribution of atmospheric sulfur
and other nutrients to crop requirement will be
estimated.

Progress: 84/01 to 84/12. Rainfall samples
were collected on an event basis at six sites
(Ames, Atlantic, Fairfax, Sigourney, Storm
Lake, and Tripoli) and on a weekly basis at the
Agronomy Farm in Boone County in Iowa. A total
of 177 samples were collected and analyzed
analyzed for F, Cl, NO₃, SO₄, PO₄, K, Na, Ca, and Mg
The pH and conductivity of each sample are also
determined. The pH values ranged from 4.6 of
one sample collected in Ames to 7.2 of a sample
in Sigourney. The means and standard deviations
of the pH values at the seven sites were: Ames,
6.1±0.5; Agronomy farm, 6.3±0.3; Atlantic,
6.6±0.4; Fairfax, 6.0±0.6; Sigourney, 6.6±0.3;
Storm Lake, 6.6±0.4; Tripoli, 6.6±0.3.
Expressed in mg/L, the mean values of NO₃-N
and SO₄-S, respectively, were 0.4 and 1.1
(Ames), 0.6 and 1.1 (Agronomy farm), 0.7 and
1.2 (Atlantic), 0.5 and 1.4 (Fairfax), 0.7 and
1.6 (Sigourney), 0.3 and 0.9 (Storm Lake) and
0.4 and 1.3 (Tripoli). Studies to evaluate the
Dionex Model 10 Ion Chromatography (IC) for
simultaneous determination of K, Na, Ca, and Mg
in diverse types of natural waters, including
rainfall and soil extracts, showed that the
results by the IC method agreed closely with
those obtained by flame photometry for K and Na
and by atomic absorption spectrophotometry for

K, Na, Ca, and Mg. The IC method is precise and
accurate and can detect as little as 0.1 mg L
of K, Na, Ca, or Mg in water samples. With the
IC method, K and Na or Ca and Mg can be
determined simultaneously in 2 mL of water in
approximately 7 min.

Publications: 84/01 to 84/12

TABATABAI, M.A. 1985. Effect of acid rain on
soils. CRC Crit. Rev. Environ. Cont. (In
press).

TABATABAI, M.A. 1984. Importance of sulphur
in crop production. Biogeochemistry
1:45-62.

BASTA, N.T., and TABATABAI, M.A. 1985.
Determination of potassium, sodium,
calcium, and magnesium in natural waters by
ion chromatography. J. Environ. Qual. (In
press).

01.046

CRIS0089414

**CHEMISTRY OF ATMOSPHERIC DEPOSITION EFFECTS ON
AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS**

GROVE J H; Agronomy; University of Kentucky,
Lexington, KENTUCKY 40506.
Proj. No.: KY00244 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize
biologically important geographical and
temporal trends in the chemical climate of
North America: to assess the effects of
atmospheric deposition on the following: the
productivity of agricultural crops, forest
trees, range lands, and soils; the chemical
composition of surface and ground waters.

Approach: Wet and dry deposition will be
collected, characterized, and chemical analysis
of entrained water soluble and insoluble and
chemical analysis of entrained water soluble
and insoluble substances completed. The role of
acid deposition in acidification of managed and
unmanaged soil profiles will be studied with
saturation extract and undisturbed core
techniques. Use of 7AL nuclear magnetic
resonance spectroscopy is proposed to
characterize the soluble aluminum chemistry of
soils under study.

Progress: 84/01 to 84/12. Studies on basic
soil acidification processes and solution Al
chemistry were continued. Soil acidification
control via lime addition was monitored under
continuous corn production at two levels of
residue management intensity. Major reductions
in strong acidity were uniformly distributed in
the moldboard plow horizon of the plots under
conventional residue management. The acidity
control was confined to the surface 5 cm of
soil in the no-tillage plots. Control of
strongly developed acidity is apparently very
difficult in reduced tillage system as the lime
reaction seems less mobile than the acid
products of nitrification. The accumulation of
organic matter at the surface of the no-till
soil appears to impede mobility of the lime
reaction as well. Corn productivity has yet to
be restored in the extremely acid no-till
plots.

Publications: 84/01 to 84/12

GROVE, J.H., BLEVINS, R.L. and BERTSCH, P.M.
1984. Preliminary indications on the
control of surface soil acidification in
no-tillage corn production with suspended
lime. Proc. Sym. Fluid Fert. Found. p.
24-30.

01.047 CRIS0077065
SOCIO-ECONOMIC FACTORS AND RURAL LAND USE

WHITE G K; Agri & Resource Economics;
University of Maine, Orono, MAINE 04469.
Proj. No.: MEO8221 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 78 to 30 SEP 83

Objectives: Determine relationships between rural land use and the employment, income, and other socio-economic characteristics of rural residents, and other owners or users of rural land. Determine the consequences of selected local, state, and national public policies affecting land use patterns and population distribution.

Approach: A sample of towns (or unorganized territories) will be selected which is representative of rural land use patterns and changes. General criteria for this selection will be based on population changes, land transfers, and use changes. A questionnaire will be developed and administered to collect primary data on land use, ownership, tenure, and characteristics and views of residents, owners, and other primary users of the land. Under the second objective, selected policy programs which influence land use such as Maine's Site Selection Law, health regulations, the 208-Quality Program, and Coastal Zone Management will be investigated. Comparative analyses of the targeted programs will be made using appropriate comparative and analytical techniques.

Progress: 78/10 to 83/09. The study had two primary objectives: 1) to determine relationships between land use, employment, income and other socio-economic characteristics of rural residents; and 2) to determine the consequences of selected state, local, and national public policies affecting land use patterns and population distribution. The first objective was completed in cooperation with eight other northeast regional states. Several separate studies were undertaken in conjunction with the second objective. One study identified the factors affecting the value of rural land in Maine. Another study examined the impact and distribution of property tax reductions associated with Maine's Farm and Open Space Tax Law. Per acre reductions ranged from \$.41 to \$19.07. Enrollment in the program reduced property taxes from 17% of reported gross farm income to 8%. Program participation was small and thus the program has not caused substantial increases in municipal tax rates to occur. A model simulating the impact of acid precipitation on forest soils and timber productivity was developed in hopes it would be appropriate to evaluate effectiveness of alternative proposals to reduce the incidence of acid precipitation in the northeast. The

model indicated very low levels of sensitivity to timber growth to a wide range of acidity. Until this result is confirmed by field trials the model will be of limited use for policy analysis.

Publications: 78/10 to 83/09

DONOHUE, D.C. 1982. The impact and distribution of property tax reductions resulting from the maine farm and open space tax law. M.S. thesis, University of Maine at Orono, 103 pp.

PALMER, C.S. 1982. A simulation model of the impact of atmospheric nitrogen deposition and intensive harvesting on spruce-fir productivity. M.S. Thesis, University of Maine at Orono, 187 pp.

01.048 CRIS0083333
EFFECT OF SIMULATED ACID RAIN ON THE GROWTH AND NUTRIENT CONCENTRATION OF THREE SPECIES OF SPRUCE

STRUCHTEMEYER R A; Forest Resources;
University of Maine, Orono, MAINE 04469.
Proj. No.: MEO9802

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 10 NOV 80 to 30 SEP 82

Objectives: Objective is to study the effects of simulated acid rain on the growth and nutrient content of three species of spruce seedlings.

Approach: This will be a greenhouse study. Two soils common to the Big Woods area of Maine will be collected. The soil will be screened, placed in plastic pots planted with six seedlings per pot and then watered with simulated rainfall ranging in pH from 7.0 to 2.0. The seedlings will be grown for 30 weeks at which time they will be harvested. The amount of dry matter produced will be determined. Seedlings will be divided into needles, stems and roots. Tissue, soil and leachate will be analyzed for Ca, Mg, K, Na, P, S and N.

Progress: 80/11 to 82/12. Twenty-four plots were established in spruce-fir stands. These plots were located on somewhat poor (Telos) and poorly drained (Monarda) soils. Both physical and chemical soil properties were studied. Results showed that biomass production was greatest on the Telos soil. Most of the available nutrients were in the organic mat. Average spruce site index was best correlated with the total nitrogen in the O(2) horizon. Of the soil properties studied, total biomass was best correlated to the acidic variables and the cation exchange capacity in the organic horizons. The data collected from the white spruce plantations showed as suspected that when age is constant, soil factors account for more of the growth differences. While the data for this study are being statistically analyzed, the numbers indicate that drainage and the calcium in the soil and tissue account for much of the growth difference.

Publications: 80/11 to 82/12

GRISI, B.F. 1982. Relationship of Chemical and Physical Properties of Telos and Monarda Soils to Site Productivity of Even-Age Spruce-Fir Stands. M.S. Thesis, Univ. of Maine, Orono, ME. 90pp.

DAVID, M.B. and STRUCHTEMEYER, R.A. 1982. Disposal of Sewage Effluent on Forested Land: Effects on Groundwater. Environ. Tech. Letters, Vol. 3, p.103-110.

FERNANDEZ, I.J. and STRUCHTEMEYER, R.A. 1982. The Composition of Equilibrium Soil Solutions from Forest Soil B Horizons. Life Sci. and Agri. Exp. Sta. Tech. Bul. 105. p.21.

01.049

CRIS0074811

CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

NORTON S A; Geology; University of Maine, Orono, MAINE 04469.

Proj. No.: ME08904 Project Type: HATCH
Agency ID: CSRS Period: 01 JAN 78 to 30 SEP 83

Objectives: Establishing and Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States.

Approach: Locate an appropriate site for a precipitation collection station as part of a national network investigation regional trends in atmospheric deposition. Install equipment as specified for regional network. Collect and ship weekly samples to a Central Analytical Laboratory for chemical analysis of SO₄(4), NO₃(3), PO₄(4), Cl⁻, NH₄(4), K, Na, Ca, Mg, pH, total and free acidity or alkalinity, and electrical conductivity. pH and electrical conductivity will also be measured at the time of collection. Encourage participation of those organizations in the state of Maine with a vested interest in the quality of atmospheric precipitation.

Progress: 83/01 to 83/12. A precipitation station was established at Greenville, Maine as part of the National Atmospheric Deposition Program (NADP). The station was originally manned (in 1979 and early 1980) by the Maine Forestry Service and located on Maine Forestry land. In mid-1980 Mr. Llew Wortman, of the Moosehead Sanitary District, assumed responsibility for sample collection, collector maintenance and analytical field measurements. Weekly monitoring has been continuous since 1979. In 1980 Norton assisted in the site location selection for two additional NADP stations in Maine. In 1981, Mr. Wortman attended the National meeting of the NADP Technical Committee in St. Louis and in 1983 he attended a training session at Champaign-Urbana. Norton has, as station supervisor attended the yearly Technical Committee meetings of NC-141 since 1979. Since 1981, Norton has served as the NADP secretary and has consequently attended the bi-annual executive committee meetings.

Publications: 83/01 to 83/12

NO PUBLICATIONS REPORTED THIS PERIOD.

01.050

CRIS0089304

CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, & MATERIALS

NORTON S A; Geology; University of Maine, Orono, MAINE 04469.

Proj. No.: ME08904 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: (To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America). Specifically, to operate one (1) NADP precipitation collection station at Greenville, Maine. (To assess the effects of atmospheric deposition on the following: a) the productivity of forest trees, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife and fish, and c) the chemical composition of surface and ground waters.

Approach: Specific Projects under investigation in FY 83 at UMD include (as listed in the proposal), B1, 2, 6; C1; D2; E1, 2; G1, 2, 4; H1, 2, 3; I1, 2.

Progress: 83/10 to 84/09. The precipitation collection station has been in operation at Greenville, Maine for this past year which is part of the National Atmospheric Deposition Program. A cooperative agreement exists with Mr. Llew Wortman of the Moosehead Sanitary District facility at Greenville, Maine to operate the site. Mr. Wortman has carried out the sample collections, field measurements, and the shipping of samples to the analytical laboratory in Urbana, Illinois. Mr. Wortman and Dr. Fernandez implemented some improvements for the Greenville station this year which included (a) purchase of a new pH meter, (b) purchase of a new conductivity meter, and (c) relocation of the collector to improve the integrity of samples collected. The Greenville Station is now officially recognized as a site in both NADP and the National Trends Network. Dr. Fernandez participated in the annual technical committee meetings in Asheville, North Carolina and was elected vice chairman of the IR-7 Forestry Effects working group.

Publications: 83/10 to 84/09

FERNANDEZ, I.J. Acid Deposition and Forest Soils: Potential Impacts and Sensitivity. In Adams, Donald D. and Walter Page (eds.). Acid Deposition Environmental, Economic, and Policy Issues. Plenum Press, NY (in press) BERNSTEN, C.M., CORLISS, J.F., FERNANDEZ, I.J., JOHNSON, D.W., JONES, H.C., III, SMITH, W.H. and LYONS, J.R. 1984. Report of the SAF Task Force on the Effects of Acidic Deposition on Forest Ecosystems. Society of American Foresters. FERNANDEZ, I.J. and CZAPOWSKYJ, M. 1984. Forest Floor Heavy Metals Levels in Low Elevation Commercial Spruce-Fir Stands in Maine. Agronomy Abstracts. Madison, Wisconsin p. 258

01.051 CRIS0092504
FOREST SOIL - TREE GROWTH RELATIONSHIPS

FERNANDEZ I J; Plant & Soil Sciences;
 University of Maine, Orono, MAINE 04469.
 Proj. No.: ME09803

Project Type: MCINTIRE-STENNIS
 Agency IO: CSRS Period: 01 OCT 84 to 30 SEP 89

Objectives: To continue an investigative program to (a) identify critical soil parameters related to tree growth in Maine forests, and (b) improve our knowledge on the suitability of sampling and measurement techniques for forest soils; to quantify the variability of forest soil properties critical to tree growth in both space and time for important species-soil type combinations in Maine; To develop quantitative information on key forest soil parameters which reflect longrange transport of air pollutants, particularly trace metals such as lead, to permit assessments now and comparisons in the future.

Approach: Both field plots and transects at selected forest sites will be used to obtain samples for analysis. Mineral soil and forest floor samples will be collected by horizon with subsequent chemical analysis for selected parameters. Site quality plots will also be assessed for elemental composition of the vegetation. Intensive sampling will be carried out on several sites in order to calculate the degree of variability encountered on uniform soil types for critical forest soil measurements.

Progress: 83/10 to 84/09. This is a new project which officially began October 1, 1984. Therefore, no work has been completed to date on this research. Preliminary work has been carried out to (a) secure commitments for personnel involved with the soil-site work, and (b) identify regional low elevation and one high elevation commercial spruce-fir forest sites to carry out forest floor trace metal analyses.

Publications: 83/10 to 84/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.052 CRIS0048479
PRECIPITATION SCAVENGING OF ATMOSPHERIC PARTICLES AND GASES

ZOLLER W H; GLOTFELTY D E; Chemistry;
 University of Maryland, College Park, MARYLAND 20742.

Proj. No.: 1090-20792-014-00S

Project Type: COOPERATIVE AGREE.
 Agency IO: ARS Period: 02 AUG 83 to 30 NOV 84

Objectives: To measure the removal of pesticide vapors from the atmosphere by fog and cloud particles and their role in the re-deposition of pesticides in non-target areas. To characterize the inorganic species associated with atmospheric aerosols and their role in affecting the scavenging efficiency of fogs and aerosols..

Approach: Samplers will be developed to collect samples of water from fogs and clouds. These will then be used to measure the pesticide content of these waters and their role in the re-deposition of pesticides in non-target areas. A sampler discriminating between dry and wet particulate in fogs will be used to investigate the role of highly adsorbent hydrophobic particles in these reactions..

Progress: 83/01 to 83/12. In the first five months of this project, we modified and tested a high-volume dichotomous sampler (virtual impactor) to separate the ambient aerosol into particles greater than 10 μ m, particles less than 10 μ m, and gaseous species. The gaseous species of interest, pesticide vapors, are retained in porous polyurethane foam or Chromosorb 102 adsorbent traps. In this mode, the sampler will be used to separate fog droplets (>10 μ m) from dry aerosol and gases in equilibrium with the fog. With minor adjustments, the sampler can be used to sample normal aerosols, with a 2.5 μ m particle cut off diameter. Other exploratory work during this period has been to examine collected fog liquid for major inorganic ions (sulfate, nitrate) by ion chromatography, and for major elements by instrumental neutron-activation analysis.

Publications: 83/01 to 83/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.053 CRIS0047438
EVALUATION OF RISK FROM LEAD AND OTHER HEAVY METALS PRESENT IN URBAN GARDEN & SMALL FARM SOILS

CHANEY R L; USDA Agricultural Research Service, Beltsville, MARYLAND 20705.

Proj. No.: 1203-20793-009-000

Project Type: INHOUSE
 Agency IO: ARS Period: 27 OCT 81 to 21 MAR 84

Objectives: Develop soil sampling and analysis methods for high metal urban soils; characterize metal sources for urban garden soils and their impact on high-risk crops; determine whether sludge compost or other amendments can prevent accumulation of soil Pb by lettuce; and determine whether amendments can reduce the availability of soil Pb to animals fed soils containing excessive Pb.

Approach: Evaluate methods for soil analysis on high metal soils with varied chemical properties; Evaluate methods of sampling community gardens; conduct a survey of Baltimore gardens to characterize the extent and sources of garden soil metal pollution; measure metal content of leafy vegetable crops sampled in urban gardens; conduct pot studies to determine whether phosphate fertilizer, limestone, or sludge compost can reduce metal uptake by leaf and root vegetables; conduct soil feeding trials with rats to assess bioavailability of soil Pb from different pollution sources, and whether soil amendments can reduce this bioavailability.

Progress: 81/10 to 84/04. Results from our survey of heavy metals in garden soils in Baltimore, MD were analyzed using a new statistical procedure which calculates the probability of Pb concentration in mapping units. Both automotive Pb emissions and Pb paint residues contributed to high accumulation of Pb in inner city soils. These results were published, and the journal prepared an editorial discussing these results. Soil-plant metal relationships in Baltimore gardens research results have been incorporated into manuscripts which are undergoing review.

Publications: 81/10 to 84/04

- MIELKE, H.W., ANDERSON, J., BERRY, K., CHANEY, R.L., LEECH, M.L. and MIELKE, P.W. 1983. Lead concentration in inner city soils as a factor in the child lead problem. Am. J. Public Health.
- CHANEY, R.L., and STERRETT, S.B. 1982. The potential for heavy metal exposure from urban gardens. In Symposium on Heavy Metals in Urban Gardens. University of the District of Columbia.

01.054 CRIS0084716
THE LIMNOLOGICAL IMPACT OF ACID RAIN ON FARM PONDS

COLER R A; Environmental Science; University of Massachusetts, Amherst, **MASSACHUSETTS** 01003.
 Proj. No.: MAS00511 Project Type: HATCH
 Agency ID: CSRS Period: 11 JUN 81 to 30 SEP 84

Objectives: Trace the impact of acid rain percolating through glacial till utilized for pasture and forestry on lake dynamics. Identify critical parameters as early warning indices of acid-rain stress on lotic systems.

Approach: Logically, an ecological study is a field study, but the problem of obtaining replicates and maintaining controls would be logistically unmanageable. Consequently, the applicant proposes to monitor, with a laboratory model over an extended period, the changes that unfold from the deposition of acid rain directly on the "pond" surface and as a subsurface accrual.

Progress: 83/10 to 84/09. The effect of acid rain and elevated aluminum on the dragonfly has been to reduce respiration and the excretion and accumulation of metabolites. Investigations of feeding and starved specimens indicate that these stresses disrupt ingestion absorption or assimilation rather than intermediate metabolism. The significantly depressed energy availing processes will likely cause a diversion of energy from growth moulting and emergence. While the dragonfly regulates its internal environment, the caddisfly seems to conform to the external environment. No homeostatic mechanism could be clearly identified. On the basis of this one detritive, the mechanical breakdown of detritus doesn't seem to be imperiled by acid rain or acid rain and aluminum. While excretion did measurably increase, respiration did not.

Publications: 83/10 to 84/09

- CORREA, M., CHIH-MING, R.A., CHIH-MING, Y. 1984. Changes in oxygen uptake and nitrogen metabolism in the dragonfly *Somatochlora cingulata* exposed to aluminum in acid waters. *Hydrobiologia* in press.
- MEDEIROS, C., COLER, R. and CALABRESE, E. 1984. A laboratory assessment of the toxicity of urban runoff on the fathead minnow (*Pimphales Promelas*). *J. Environ. Sci. Health*, A19(7), 847-861.
- TEASE, B. and COLER, R. 1984. The Effect of Mineral Acids and Aluminum from Coal Leachate on Substrate Periphyton Composition and Productivity. *J. Freshwater Ecology*, Vol. 2, No. 5 August.

01.055 CRIS0080231
RECYCLED WASTE PRODUCTS: EFFECTS ON PLANT DISEASES, SYMBIOTIC ASSOCIATIONS, AND REPRODUCTIVE PROCESSES

FEDER W A; BAKER J H; BAKER J H; Plant Pathology; University of Massachusetts, Amherst, **MASSACHUSETTS** 01003.
 Proj. No.: MAS00474 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 84

Objectives: Determine the effects of liquid and solid waste products (sludges, composts, ashes, etc.) on plant performance and yield as affected by: Incidence and severity of root and foliar disease. Incidence and effectiveness of beneficial symbiotic root infections. Changes in plant reproductive processes and uptake and accumulation of nutrients and heavy metals.

Approach: Vegetable, flowers, fruit and ornamentals grown in field plots and greenhouse onsoils treated with liquid sludge, composted sludge and incinerator ash. Effects on total plant performance will be determined.

Progress: 83/10 to 84/09. Results (9 yrs) indicate that incinerator ash residue will leach heavy metals at a rate dependent on the amount of fly ash in the residue and soil chemistry of the disposal site. Acid rain, pH 4.0 has little effect on the residue but leaches Cd&Zn & soluble salts within 21 days after exposure to rainfall. Cd, Zn and Pb are found in the peat layer below the ash in the wetland. Soluble salts leach directly into the ground water and are carried away. The fly ash component of incinerator ash residue constitutes the greatest environmental hazard. The degree of adverse impact of ash residue is directly proportional to the percent fly ash in that residue. Bottom ash residue with no fly ash component is environmentally safe, even beneficial because of its high buffering capacity. The fly ash, with its very high heavy metal content should not be disposed of by landfilling. This remains a growing problem, especially in the Northeast where refuse to energy incinerators are growing in popularity and environmentally safe landfill sites are at a premium. This problem must be factored into land use planning in the Northeast.

Publications: 83/10 to 84/09

FEDER, W.A. and MIKA, J.S. 1984. Movement of fly ash-generated Pb and Cd through soil columns leached with acid precipitation. AAAS Annual Meeting Poster 237 NY city, NY. May 1984.

01.056 CRIS0074071
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

MANNING W J; FEDER W A; Plant Pathology; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00435 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors.

Approach: Whole plant responses of tolerant and sensitive cultivate cultivated plants and forest trees will be identified and used to determine responses to ozone and sulfur dioxide. Plant indicators of air pollution will be determined and used to determine air quality through development of dose/response cures. Work will continue on ozone and sulfur dioxide effects on root disease and nodulation of legumes. The effects of elevated heavy metal content of soils on plant sensitivity to pollutants will be determined. Work will begin on acid rain/gaseous air pollutant interactions.

Progress: 83/10 to 84/09. Set up ozone monitoring at Arnold Arboretum, Boston, MA about 10 miles east of Suburban Experiment Station in Waltham, MA. This allowed us to measure air quality on site of the Harvard University, Arboretum large lilac variety collection where leaf roll symptoms have been observed for many years. We could then compare air quality at Waltham and at the Arboretum. Both sites had very similar air quality patterns during summer of 1984. High and prolonged ozone episodes occurred at both sites during late June, early July 1984. Values ranged from 0.1-0.2 ppm for at least 4 hours daily for as long as 3-6 days at a time. Leaf roll symptoms occurred later in the summer at the Arboretum on supposedly ozone-susceptible varieties of lilacs. The degree of injury seemed to relate to ambient ozone levels at the Arboretum. Greenhouse lilacs exposed to chronic low levels (0.06-8ppm) for 5 hrs/day for 5-8 weeks developed flecking and glazing symptoms. Typical leaf roll necrosis symptoms developed on *Syringia vulgaris* cv Marie Legraye, Miss Ellen Wilmot, and Primrose, but only bronzing occurred on cv Congo. This conformed data obtained the previous winter. A complicating factor may be what appears to be feeder root deterioration in the lilacs growing at the Arboretum. I suspect a nematode problem and we will look at this as soon as the ground thaws next spring.

Publications: 83/10 to 84/09

DAMICONE, J.P., MANNING, W.J. and FEDER, W.A. 1984. Effects of ozone and *Fusarium oxysporum* alone and in combination on growth early maturing soybean lines. *Phytopathol.* 74 (7):843.

COLLEY, D.R., MANNING, W.J. and FEDER, W.A. 1984. Differences in alfalfa cultivar sensitivity to ozone. *Phytopathol.* 74 (7):843.

01.057 CRIS0082978
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS & MATERIALS

FEDER W A; CRAKER L E; Suburban Exper Station; University of Massachusetts, Waltham, MASSACHUSETTS 02154.
 Proj. No.: MAS00496 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils.

Approach: In addition to maintaining 2 NADP/IR7 collection sites, studies of the plant/soil/air rainfall interactions will be made to discover if atmospheric deposition predisposes plants to injury by foliar or root pathogens/pests and if plant injury is enhanced or reduced by inter-actions between atmospheric deposition and other air pollutants like ozone, sulfur dioxide, and/or particulate matter. The effects of changes in soil chemistry from atmospheric depositions upon mycorrhizal and nitrogen fixation organisms will be examined. The changes in soil chemistry due to atmospheric deposition will be studied for their effects on the mobilization of toxic elements like Al and the subsequent effects of released aluminum upon aquatic ecosystems. The movement of trace heavy metals from atmospheric deposition through terrestrial ecosystems will be followed and the effects quantified.

Progress: 83/10 to 84/09. Continued to operate wet/dry collectors for NADP network. Also participated in state-wide survey of aquatic lake/pond/stream pH values and fairly high alkalinity values, indicating little rainfall effect upon pH of aquatic areas surveyed. Soil solution pH rather than rainfall pH controlled movement of heavy metals through two soil types. Agriculturally, soil chemistry and soil solution chemistry will regulate the magnitude of the acid rainfall effect on plants growing in any soil. This seems to confirm the fact that crop plants growing in good agricultural soils properly cared for culturally will not be adversely affected by acid precipitation, per se. It is important to appraise farmers of this information, while at same recognizing that the ction of acid rainfall over forest ecosystems may have a different impact, of which to date, we have little understanding. This project will be continued under a new Hatch Project Number, as of October 1, 1984.

Publications: 83/10 to 84/09

MIKA, J. S. and WILLIAM A. F. 1984. The movement of incinerator fly ash and residue-generated Cd, Pb and Zn through soil columns leached with acid precipitation, APCA Northeast Atlantic International Section Technical Meeting.

pine-Grayling sand ecosystem. M.S. Thesis. Michigan State University, E. Lansing, 189p.

01.058

CRISO074631

CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

HART J B; Forestry; Michigan State University, East Lansing, MICHIGAN 48824.

Proj. No.: MICLO1282-H Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 28 DEC 84

Objectives: Establishing an Atmospheric Deposition Network to determine special & temporal trends in the supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter deposited in various regions of the United States. Organizing and coordinating research in the SAES, FS, and other research institutions & agencies on the effects of changes in atmospheric deposition on: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters: The health & productivity of domestic food animals, wildlife, and fish; and the corrosion of metals, painted surfaces, masonry, and other materials in machinery or structures.

Approach: Establishment of two monitoring sites in Michigan. Weekly analysis of collected precipitation & dry particulates. Use trends to find effects on forest growth & reproduction.

Progress: 83/01 to 83/09. Research activities were pursued in this project prior to initiation of Project IR-7. Two wet-dry deposition monitoring sites are maintained as part of the National Atmospheric Deposition Program network and National Trends Network: one at Kellogg Biological Station in southwest lower Michigan; and one at the University of Michigan Biological Station in north central lower peninsula Michigan. Precipitation acidity has ranged from extremes of 3.8 to 7.2 with a normal range of 4.2 to 5.7. Simulated acid precipitation of pH 2.5 and below adversely affected greenhouse germination and survival of jack pine. Foliar necrosis and stem lesions were produced on seedlings grown at pH 3.0 and below. Preliminary results indicate episodic simulated acid precipitation of pH 3.0 has no significant effect on survival, growth, or foliar appearance of one-year old jack pine seedlings or competing species of Carex sedge. Interpretation of the monitoring network results using information from previous research indicate that neither the extremes or normal acidity ranges are sufficient to preclude the germination and early development of Pinus banksiana on typical Udipsamment soils of the region.

Publications: 83/01 to 83/09

MACDONALD, N.W. 1983. The effects of simulated acid precipitation on regeneration and soils in the Jack

01.059

CRISO091453

CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

HART J B; Forestry; Michigan State University, East Lansing, MICHIGAN 48824.

Proj. No.: MICLO1447 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To access the effects of atmospheric deposition on a) productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife, and fish; c) the chemical composition of surface and ground waters; and d) atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Deposition sites will be instrumented and maintained in specific ecosystem strata occurring in Michigan according to IR-7/NADP protocol. Regional and network evaluation of monitoring data will be conducted. Effects of past, present and potential atmospheric deposition will be studied by vegetative, soil and hydrologic components. Statistically designed experiments and sample collections will be conducted on important components of individual ecosystems, and groups of systems, to test hypothesized effects and quantify relationship. These studies, where appropriate, will be conducted in cooperation with other states and regions. Biologically and economically feasible strategies for control and treatment of atmospheric deposition effects will be developed from these results.

Progress: 84/01 to 84/12. Two wet-dry deposition monitoring sites were maintained as part of the National Atmospheric Deposition Program network and National Trends Network: one at Kellogg Biological Station in southwest lower Michigan; and one at the University of Michigan Biological Station in north central lower peninsula Michigan. Precipitation acidity has ranged from extremes of 3.8 to 7.2 with a normal range of 4.2 to 5.7. Evaluation of the monitoring network results and recent research on Pinus banksiana regeneration indicate that neither the extremes or normal acidity ranges are sufficient to preclude the germination and early development of jack pine forests on typical Udipsamment soils of the region. Approximately 40% of Michigan soils have been determined to be sensitive or slightly sensitive using published criteria. Most are predominately forested soils. Current research is reevaluating the sensitivity of Michigan and Upper great lakes forested soils to atmospheric deposition and the long-term effects of nutrient depletions and acidification.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

establishment, competing vegetation, and pest damage.

01.060 CRIS0079282
EFFECTS OF ACID PRECIPITATION ON NUTRIENTS IN MICHIGAN FOREST SOILS

BOYLE J R; School of Natural Resources;
University of Michigan, Ann Arbor, MICHIGAN
48109.
Proj. No.: MICY00048
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 DCT 79 to 30 SEP 82

Objectives: Evaluate effects acid rainfall and snowmelt on essential plant nutrients in forest soils of northern Michigan.

Approach: Simulated acid rain will be applied to field plots in three forest sites representing a range of productivity for aspen. Soil percolate will be collected with porous ceramic cup lysimeters. Based on soil chemical analyses and on percolate analyses, evaluation will be made of the effects of acid rain on nutrient mobilization and leaching. Snowmelt lysimeters will be used to collect early-spring snowmelt water for analysis of acidity to evaluate the suspected impact of this short-term, seasonal phenomena on leaching of nutrients.

Progress: 83/01 to 83/05. No progress reported this period.

Publications: 83/01 to 83/05
CDFFEY-FLEXNER, D. 1983. Interception and modification of acidic precipitation by bigtooth aspen forest canopies in northern Lower Michigan. M.S. Thesis. Univ. Michigan, Ann Arbor. 207 p.

01.061 CRIS0096150
PINE STANDS: EFFECTS OF INCREASED NITROGEN AVAILABILITY

RICHTER D D; School of Natural Resources;
University of Michigan, Ann Arbor, MICHIGAN
48109.
Proj. No.: MICY00066
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 DCT 85 to 30 SEP 90

Objectives: To evaluate effects of increased nitrogen availability on biotic nitrogen cycling, seedling growth, moisture stress, and pest damage in young red pine (*Pinus resinosa*) stands.

Approach: Greenhouse and field studies will evaluate under controlled nitrogen and moisture regimes, how nitrogen availability affects seedling response to moisture stress. In addition, nitrogen will be added periodically to replicated plots in ten young pine stands (at rates that simulate increased nitrogen inputs in acid deposition) to evaluate the potential for increased atmospheric inputs of nitrogen to alter nitrogen cycling, stand

01.062 CRIS0078508
THE CHEMICAL PROPERTIES OF SOILS AS AFFECTED BY SOIL ORGANIC MATTER

BLODM P R; Soil Science; University of Minnesota, St Paul, MINNESOTA 55108.
Proj. No.: MIN-25-045 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 82 to 30 JUN 87

Objectives: Determine the ion-exchange preference for divalent ions in calcium peat and calcium-humate. Determine the enthalpy and entropy changes for divalent metal ion adsorption on sodium-humate. Determine the nature of the chromophoric species associated with anionic charge sites in humic and fulvic acid. Determine the effect of metal ions on the vibration modes of phenolic and carboxylic groups in humic and fulvic acid. Determine the effect of organic acids on the dissolution kinetics of aluminous minerals.

Approach: Humic acid fulvic acid and acid washed peat will be used to study metal ion binding in soil organic matter. Methods developed for the study of the thermodynamics of ion binding in weak acid polyelectrolytes and weak acid ion exchanges will be applied. Spectroscopic methods shown to be useful in the study of metal ions in biopolymers will also be applied. Dissolution of gibbsite, Al (OH)₃ will be studied in solutions containing organic anions.

Progress: 84/01 to 84/12. Calcium - barium exchange in an acid washed peat demonstrated the importance of ionic concentration on ion exchange in soil organic matter. At low ionic strength, 0.0012 M and 0.0025 M, Ba was adsorbed preferentially to Ca but at higher ionic strength, .005 M, the relative preference was reversed. The data suggest that for alkaline earth ions the formation of carboxylate complexes is important at higher ionic strengths. Field data from Calciaquolls in western Minnesota showed that soil solutions are typically over saturated with respect to the precipitation of CaCO₃. The over saturation leads to high HCO₃⁻ which causes iron chlorosis in soybeans. Laboratory experiments demonstrated soluble soil organic matter adsorbs strongly on calcite surfaces greatly inhibiting precipitation. A numerical model for predicting the long-term impact of acidic deposition to soils and designed to operate using readily available data was developed. Work is continuing to refine the model with respect to the effects of pH drop and soluble organic matter on mineral weathering.

Publications: 84/01 to 84/12
INSKEEP, W.P. and BLODM, P.R. 1984. Calcium Carbonate Superturation in Soil Solutions of Calciaquolls. Agron. Abst. 1984: 178.

BLOOM, P.R., METER, K. and CRUM, J.R. (In Press). A Titration Method for the Determination of Clay-Sized Carbonates. Soil Sci. Soc. Am. J.
 BLOOM, P.R. and GRIGAL, D.F. (In Press). Modelling Soil Response to Acidic Deposition in Non-Sulfate Adsorbing Soils J. Environ. Qual.

01.063 CRIS0089150
CHEMISTRY OF ATMOSPHERIC DEPOSITION: EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, & MATERIALS

HENDERSON G S; Forestry Fisheries & Wildlife; University of Missouri, Columbia, **MISSOURI** 65211.

Proj. No.: MD-00163-1 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, range lands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints, and other productivity coatings, and other material in machinery or structure.

Approach: NADP monitoring stations are presently established at University Forest near Poplar Bluff and at the Ashland Wildlife Area. These collection stations will continue to be operated with samples analyzed to characterize the chemistry of rainfall in Missouri. Additional research will be conducted on soil fertility as affected by acid deposition. Plots which have received quarterly additions of accelerated acid inputs will be used in this study. Base status and nitrogen transformations will be most intensively studied.

Progress: 84/01 to 84/12. Precipitation monitoring at two NADP stations was continued in Missouri. The data from these stations continue to show that Missouri's precipitation is acid with a pH averaging between 4.5 and 4.6. Chemical analyses on the samples further indicate that the precipitation is dominated by sulfate with lesser amounts of nitrate. Soil in plots which have been artificially acidified for the past two years were sampled and subjected to analysis. No significant changes in soil acidity were observed among the different acidity treatments. This experiment is being continued and soil will be sampled again next spring. A major research project designed to evaluate the effects of soil aluminum on tree root growth was installed this year. The study utilizes root ingrowth cores constructed from soil treated as as to create a wide range of extractable aluminum concentrations to quantify root growth changes. The study is being conducted at three sites with three vegetation types: Oak-Hickory in Missouri, Loblolly Pine in Mississippi, and a northern hardwoods -

spruce - hemlock mixture in New York.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.064 CRIS0075343
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

VERMA S B; Agri Engineering; University of Nebraska, Lincoln, **NEBRASKA** 68583.
 Proj. No.: NEB-11-051 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish and maintain an atmospheric deposition monitoring station as part of a national network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States.

Approach: An automatic sensing wet/dry precipitation collector will be installed at the University of Nebraska Field Laboratory at Mead. This instrument consists of a two-container system with a movable lid designed to expose the "wet" and cover the "dry" container during periods of precipitation, and vice versa during dry periods. Samples of precipitation and dry particulate matter will be collected on a regular weekly schedule, and shipped in specially provided containers to a central analytical laboratory for analysis. Precautions will be taken to avoid contamination of precipitation samples during collection, transport and storage prior to analysis.

Progress: 83/01 to 83/09. As part of a national network developed in cooperation with the National Atmospheric Deposition Program (NADP), an atmospheric deposition monitoring station was established at the University of Nebraska Field Laboratory at Mead, a rural location in east central Nebraska. Precipitation was collected using an automatic sensing wet/dry precipitation collector and a recording raingauge. Samples were collected every Tuesday on a weekly basis. Samples were then shipped in special containers to the NADP Central Analytical Laboratory in Champaign, Illinois for detailed analysis. Data for the period from January, 1979 to December, 1982 have been analyzed. Average annual precipitation for the four year period was 65 cm (25.6 inches), significantly lower than the long term precipitation normals for the region. Average pH value for the study period was 5.79, indicating nearly neutral conditions. The pH value during individual event weeks varied from 4.2 to 7.6. Lowest pH values tended to occur generally in the fall and winter months. Concentrations of SO₄(4)-S, NO₃(3)-N and NH₄(4)-N in the precipitation ranged from 0 to 6.6 mg , 0.1 to 4.9 mg and 0.01 to 6.3 mg , respectively, for the four-year period. Maxima in concentration of these constituents occurred primarily in the fall and winter months and minima occurred in the spring and summer months.

Publications: 83/01 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

01.065 CRIS0088967
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS AND
MATERIALS**

VERMA S B; Agri Meteorology & Climatology;
University of Nebraska, Lincoln, NEBRASKA
68583.

Proj. No.: NEB-27-002 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of Nebraska and North Smerica.

Approach: The objective will be achieved by continuing to monitor atmospheric deposition employing an automatic sensing wet/dry precipitation collector installed at the University of Nebraska Field Laboratory at Mead. This collector will be maintained as part of a national network (NADP). Trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation will be characterized.

Progress: 84/01 to 84/12. An atmospheric deposition monitoring station at the University of Nebraska Field Laboratory, Mead was maintained as part of a national network in cooperation with the National Atmospheric Deposition Program (NADP). Analysis of precipitation data for the five year period, 1979-83 is presently in progress. The five year average for SO(4)-S concentration was 0.95 +/- 0.07 mg - . SO(4)-S concentrations ranged from 0.09 to 5.5 mg - . NO(3)-N concentration varied from a minimum of 0.02 mg - to a maximum of 4.9 mg - , with an average of 0.54 +/- 0.04 mg - . NH(4)-N concentration averaged at 0.84 +/- 0.06 mg - . The pH values of precipitation at Mead over the five-year period had a mean of 5.71 +/- 0.06, with a range of 4.16 to 7.64. High pH values were observed generally in the spring and summer months. Low pH values tended to occur primarily in the fall and winter seasons.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

01.066 CRIS0048883
**IMPACT OF FOREST MANAGEMENT AND ACID
PRECIPITATION ON NUTRIENTS IN SOIL AND WATER**

PIERCE R S; FEDERER C A; HORNBECK J W;
Northeastern Forest Expt Stat, Durham, NEW
HAMPSHIRE 03824.

Proj. No.: NE-1652 Project Type: INHOUSE
Agency ID: FS Period: 07 JUL 83 to 07 JUL 88

Objectives: To evaluate how nutrient cycles in spruce-fir, northern hardwood, and central hardwood ecosystems are affected by forest management practices, acid precipitation, or their combined influences; and to operate the

Hubbard Brook Experimental Forest as a Biosphere Reserve.

Approach: Develop means to predict long-term impacts of repeated harvesting and silvicultural practices including selection cutting, strip-cutting, clearcutting, and the severe alteration produced by whole-tree harvesting on soil nutrients and site productivity. Nitrogen mineralization, nitrification, leaching, denitrification, fixation, and plant uptake will be studied in both field and laboratory. Simulation models of the effect of nitrogen stress on long-term forest productivity will be further developed. Quantify the impacts of acid deposition on soil and water chemistry in forest ecosystems through deposition monitoring, measuring concentration of elements in soil solution, quantifying soil vulnerability and studying nutrient availability.

Progress: 83/10 to 84/09. In a comparison of two forms of even-aged management, block clearcutting and progressive strip cutting, the results show: (1) block clearcutting caused water yield increases of 673 mm over 10 years following harvesting, versus 393 mm for strip cutting; (2) with careful logging, soil movement and stream sediment can be minimal on both management types; (3) nutrient leaching of calcium and nitrogen to streams for the 10 year period were 27 kg ha and 22 hg ha respectively for the strip cut watershed whereas the block clearcut losses were 40 kg ha and 59 kg ha respectively. Such losses may not have adverse impacts on soil nutrient capital if harvest intervals are > 70 years. Strip cutting provided a more favorable mix of commerial species (yellow birch and sugar maple) after 10 years. The buffer capacity of forest soils (to buffer acid rain) in ME, NH, and CT was closely related to organic matter, the latter an easy parameter to measure. In spite of this mineral soil in most New England forest soil usually has much larger buffer capacity than organic layers because of the greatest volume. A study of 6 remote ponds in the White Mountains of New Hampshire to observe the susceptibility to acid rain showed that the characteristics of the watershed, including geologic materials, soils, vegetation, soil-water residence time, runoff pathways and land-use, all contribute to the chemistry of the pond. Pond-watershed interactions must be an integral part of any study of pond acidification.

Publications: 83/10 to 84/09

BUSO, D.C.; MARTIN, C.W.; HORNBECK, J.W.
1984. Potential for acidification of six remote ponds in the White Mountains of New Hampshire. Research Report No. 43. Burham, NH: Water Resources Research Center, University of New Hampshire.
TRITTON, L.M.; VALENTINE, H.T.; FURNIVAL, G.M. 1983. A new procedure for estimation of tree biomass and nutrient content. In: Mesures de biomasses et des accroissements forestiers. Orleans (France), 3-7 October 1983. Ed. INRA

01.067 CRIS0006306
**ORIGIN, TRANSFORMATION, AND MANAGEMENT OF
 NITROGEN IN SOILS, WATERS, AND PLANTS**

ALEXANDER M; HICKS J R; MINOTTI P L; Agronomy;
 Cornell University, Ithaca, **NEW YORK** 14853.
 Proj. No.: NYC-125457 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 DEC 83

Objectives: Establish and characterize factors governing gains and losses of nitrogen, particularly nitrate in soils, waters and plants.

Approach: The kinetics of denitrification and the ecology of the responsible microorganisms will be investigated. The possibility of nitrosamine formation during nitrate metabolism in natural habitats will be studied. Selected nitrate-accumulating vegetables will be studied after harvest to suggest practical handling methods which maintain high quality and minimize nitrate loss with subsequent nitrate accumulation. Emphasis will be placed on the effects of temperature, atmospheric composition, physiological age, plant species, variety, nitrogen fertilization and contamination. The role of microorganisms and plant enzymes will be considered.

Progress: 83/01 to 83/12. Nitrification and N mineralization were inhibited by rain at pH 3.5 or 4.1 applied in 26 d at normal rates (8.3 cm per month). Application of 3 or 9 times ambient rates in 26 d still inhibited the oxidation of added ammonium. Mineralization was inhibited only in soil treated with pH 4.1 rain at 9 times the ambient rate of precipitation. Simulated acid rain suppressed nitrification but not N mineralization after application for 56 d at 6 times the normal rate. Samples of the organic horizon (O2) of an Adirondack soil treated with rain at pH 3.5 containing the usual contrations of heavy metals lost 10 percent more inorganic N than soil treated with rain containing no heavy metals. In soil treated with pH 5.6 rain, the loss of inorganic nitrogen was 5 percent greater in soils not receiving heavy metals than those in which the rain contained the heavy metals. N mineralization and nitrification rates were measured in soil samples after treatment with simulated rain at pH 3.5 or 5.6 had ended. In these soils treated with pH 3.5 rain, mineralization and nitrification were less in soil treated with the heavy metals. At pH 5.6, mineralization was greater and nitrification was slower in soil receiving the heavy metals. To determine which soils are more sensitive to acid rain, 12 soils with a range in pH and organic matter levels and texture were exposed to rain at pH 5.6, 4.0 and 3.5.

Publications: 83/01 to 83/12

KLEIN, T.M., KREITINGER, J.P. and ALEXANDER, M. 1983. nitrate formation in acid forest soils of the Adirondacks. Soil Sci. Soc. Am. J. 47:506-518.

CHANG, F.H. and ALEXANDER, M. 1983. Effects of simulated acid precipitation on growth and nodulation of leguminous plants. Bull. Environ. Contam. Toxicol. 30:379-387.

CHANG, F.H. and ALEXANDER, M. Effects of simulated acid precipitation on decomposition and leaching of organic carbon in forest soils. Soil Sci., in press.

KLEIN, T.M., NOVICK, N.J., KREITINGER, J.P. and ALEXANDER, M. Simultaneous inhibition of carbon and nitrogen mineralization in forest soil by simulated acid precipitation. Bull. Environ. Contam. Toxicol., in press.

01.068 CRIS0087659
**CHEMICAL PROCESSES CONTROLLING INTERACTIONS
 BETWEEN ACID PRECIPITATION AND FOREST SOILS**

RIHA S J; JAMES B R; Agronomy; Cornell University, Ithaca, **NEW YORK** 14853.
 Proj. No.: NYC-125555

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 JUL 82 to 30 SEP 86

Objectives: Measure changes in the ionic composition of the solution of various horizons of acid forest soils; explain these effects with respect to chemical mechanisms controlling the solubility of various ions; test our hypotheses by selecting soils which on the basis of previous experiments we would expect to respond differently with soils which on the basis of previous experiments we would expect to respond differently with respect to Al and base leaching after input of strong acids at the surface and subject whole soil profile columns to leaching with strong acids.

Approach: Based on hypotheses developed from the behavior of mineral acids added to organic horizons studied under controlled experimental conditions, similar in-depth experimental approaches than will be used to learn what further reactions occur in the lower horizons. After observing changes in solution and soil chemistry with depth and elucidating possible mechanisms to explain the changes, whole soil profiles will be reconstructed in columns and used to test the combined hypotheses derived from the study of each horizon separately.

Progress: 84/01 to 84/12. Initial research aimed to identify changes in the equilibrium solution chemistry of organic surface horizons of 6 forest soils acidified with 0 to 20 cmol H kg soil under controlled laboratory conditions. Previous experiments had demonstrated no differences between the effects of HNO₃(3) and H₂SO₄(4) on the solution composition of these organic horizons. The proton buffer capacity of these horizons ranged from 17 to 34 cmol H kg pH unit. The high Ca saturation of exchange sites (93-218%) resulted in the predominance of H for Ca exchange upon acidification of horizons. In contrast, the concentrations of Mg, K and Mn changed relatively little upon acidification. Basic cations were not replaced by H on an equivalent basis but only accounted for 14 to 62% of the proton buffering. Protonation of soluble and solid phase weak acid functional groups also appeared to contribute significantly to proton buffering. In these surface organic horizons, soluble Al generally was less than 1%

of the cations in solution on an equivalent basis. Changes in soluble Al upon acidification indicated that nonlabile and labile forms of Al can increase, decrease or not change. Nonlabile complexes were the dominant forms of soluble Al in organic surface horizons above pH 4. Labile Al comprised an increasing percentage of total Al as pH decreased, especially below pH 3. Results indicated that pH alone was a poor predictor of total and nonlabile Al in solution, but a better predictor of the ratio of soluble carbon-to-Al.

Publications: 84/01 to 84/12

JAMES, B.R. and RIHA, S.J. 1985. Soluble aluminum in acidified organic surface horizons of forest soils. Can. J. Soil Sci. In press.

01.069 CRIS0096658
ACIDIC DEPOSITION AND MOLYBDENUM AVAILABILITY IN FOREST SOILS: IMPLICATIONS FOR FOREST PRODUCTIVITY

HOWARTH R W; Ecology and Systematics Sec; Cornell University, Ithaca, NEW YORK 14853. Proj. No.: NYC-183571

Project Type: MCINTIRE-STENNIS

Agency ID: CSRS Period: 06 AUG 85 to 30 SEP 88

Objectives: The productivity of northern hardwood forests is limited by nitrogen. Molybdenum is required for nitrogen fixation and for nitrate assimilation by plants and microbes, and so changes in molybdenum availability can affect forest productivity by changing rates of nitrogen cycling in forest soils. This study will quantify the effect of acidic deposition on availability of molybdenum within forest soils.

Approach: We will measure available molybdenum in a variety of forest soils in the Adirondack Mountains, in the White Mountains of New Hampshire, and in the forests of central Maine. Available molybdenum will be measured by anion exchange resin extraction. We will also measure concentrations of molybdenum in leaf tissue from these sites. The effect of changing the acidity of soils on molybdenum availability for each soil type will be determined in laboratory experiments.

01.070 CRIS0091190
EFFECTS OF ACID RAIN ON FOREST ECOSYSTEMS: AN EVALUATION OF CURRENT EVIDENCE

BURGESS R; MANION P; MITCHELL M J; School of Biology Chem & Ecol; State University of New York, Syracuse, NEW YORK 13210. Proj. No.: NYZ-2222-01-008 Project Type: STATE Agency ID: OCI Period: 01 JUN 83 to 30 NOV 84

Objectives: To prepare an objective evaluate of current literature on acidic deposition to determine if there is evidence that indicates that there are impacts on forest growth due to that deposition. Included will be an analysis

of the extent of the literature pertinent to specific questions raised by the sponsors.

Approach: Literature germane to the effects of acid rain on forest ecosystems will be collected, collated, and categorized. Literature will be categorized three ways: geographic region, ecosystem type, and nature of the document and evaluated from two perspectives: nature and credibility of the data and applicability of the conclusions.

Progress: 83/06 to 84/08. Published literature was extensively surveyed for information on the effects of acidic deposition on forest ecosystems in the northeastern U.S. Over 700 references were located, read, and analyzed for scientific rigor, applicability of data, methods of sampling, and conclusions drawn. Current evidence is summarized on pollutant emissions and acidic deposition trends, U.S. data are compared with the chemical climate in Germany, and the effects of acidic deposition on forests, aluminum-plant-soil interactions, general forest decline, and dieback in stands of red spruce are discussed. Precipitation chemistry and dendroecological evidence for forest decline were utilized to infer the status of current knowledge concerning acid rain and its potential effects on forest ecosystem growth, productivity, and stability. Major conclusions reached are: 1. There has been dieback of red spruce in the northeastern U.S. in the past 25 years, but the direct, or more probably, cause has not been identified. 2. There is no identifiable threshold concentration of acidic deposition below which it is possible to state that forest ecosystem damage does not occur. 3. None of the mechanisms of alleged impact of acidic deposition on forests can be individually, unequivocally, or directly tied to the dieback of red spruce or other species at this time. 4. Periodic regional drought is strongly implicated in red spruce dieback, but the explicit role of moisture stress in the overall syndrome has been determined.

Publications: 83/06 to 84/08

BURGESS, R.L., DAVID, M.B., MANION, P.D., MITCHELL, M.J., MOHNEN, V.A., RAYNAL, D.J., SCHAEDEL, M. and WHITE, E.H. 1984. Effects of acidic deposition on forest ecosystems in the northeastern United States: An evaluation of current

01.071 CRIS0089623
ALUMINUM-LIGAND INTERACTIONS IN A FORESTED ECOSYSTEM, PRIOR AND FOLLOWING CLEARCUTTING

MITCHELL M J; School of Biology Chem & Ecol; State University of New York, Syracuse, NEW YORK 13210. Proj. No.: NYZ-2360-01-002 Project Type: STATE Agency ID: OCI Period: 15 JUL 82 to 31 DEC 84

Objectives: To evaluate the response of soil and solution chemistry to whole-tree harvesting, specifically by evaluating the mechanisms that control the interactions between the sulfur and nitrogen cycles and aluminum cycling and the mechanisms by which

aluminum influences other elemental cycles.

Approach: Streams, groundwater, and soil in two adjacent watersheds--one of which will be clearcut in 1983--will be sampled periodically and analyzed for critical parameters. Laboratory titration will indicate the soils' responses to strong acids. A chemical equilibrium model will be used to analyze all collected data.

Progress: 83/10 to 84/09. Sulfur constituents were measured in samples from 16 pits at three elevations at Hubbard Brook, New Hampshire. Carbon-bonded sulfur, ester sulfate, sulfate, reduced non-sulfate inorganic sulfur, and total sulfur were determined on all samples. Concentrations of all constituents varied among pits, but generally similar to a hardwood site studied at the Huntington Forest, New York, with organic horizons dominating. Dynamics of sulfur were examined by adding S-SO₄(4) to three horizons. Incorporation of sulfate into organic sulfur forms was found to be an important process and was dependent on horizon characteristics. Adsorption of sulfate dominated in the Bh and to a greater extent in the Bsl horizons. The influence of immobilization-mineralization and adsorption-desorption reactions on S movement through forest soils was evaluated.

Publications: 83/10 to 84/09

FULLER, R.D., DAVID, M.B. and DRISCOLL, C.T. 1984. Sulfate adsorption relationship in some forested spodosols of the northeastern U.S. Soil Sci. Soc. Amer. J. (in press).
SCHINDLER, S.C., MITCHELL, M.J., SCOTT, T.J., FULLER, R.D. and DRISCOLL, C.T. 1984. Incorporation of S-sulfate into inorganic and organic sulfur constituents of two forest soils (in review).

01.072 CRIS0096269
ACIDIC DEPOSITION AND ADIRONDACK FOREST SOIL FERTILITY: AN APPRAISAL

WHITE E H; RAYNAL D J; MITCHELL M J; School of Forestry; State University of New York, Syracuse, NEW YORK 13210.
Proj. No.: NYZ-2533-20-001 Project Type: STATE
Agency ID: OCI Period: 12 MAR 85 to 31 DEC 89

Objectives: To test hypothesis on the potentially different impacts of acidic deposition on tree growth for different species and contrasting site conditions.

Approach: (1) Stem analysis techniques will be used to obtain a historical record of annual volume increment and a time series of wood volume produced per unit of cambium of given age and crown position. (2) Multiple regression statistics will be used to determine that portion of growth variation accounted for by climatic variables and age, thus providing information on growth trends related to acidic deposition. (3) Results will be compared for trees thought to represent a range of susceptibility to injury from acidic deposition. (4) Dendrochronological techniques will be used concurrently to establish the

relationship between increment core and stem analysis measurements. (5) Tree growth patterns will be correlated with nutrient levels.

01.073 CRIS0086262
SULFUR CONSTITUENTS OF AN ADIRONDACK FOREST SOIL

MITCHELL M J; Biology Chemistry & Ecology; State University of New York, Syracuse, NEW YORK 13210.
Proj. No.: NYZ-2224-01-014 Project Type: STATE
Agency ID: OCI Period: 01 MAR 81 to 28 FEB 83

Objectives: This project will establish the major inorganic and organic sulfur constituents of a forest soil which has been subjected to acid precipitation. Since sulfate is the dominant anion of acid precipitation, an understanding of the fate of this ion in forest soils is of critical importance. The effect of oxidation reduction potential (Eh) and seasonal fluctuations on the sulphur constituents of Adirondack Mountain soil will be determined and utilized in expanding our understanding of sulphur dynamics in forest ecosystems.

Approach: Within the Huntington Forest of the College of Environmental Science and Forestry, three sample sites along an Eh-moisture gradient will be used. Soil samples will be taken in May, July and October and divided into horizons: moisture, Eh, total organic carbon, total nitrogen, nitrate, ammonia, total sulphur, carbon-bonded sulphur, ester-sulfate, exchangeable sulfate, available sulfate, sulfide and total inorganic sulphur will be determined for each sample.

Progress: 81/03 to 83/02. Sulfur (S) constituents, microbial biomass, and sulfohydrolase activity were determined for each soil horizon at both hardwood and conifer sites in a Becket soil (Adirondack Mountains, New York). Total S was greatest in the O horizons with 2,010 and 1,690 µg S/g in conifer and hardwood solums, respectively. Mineral soil had a maximum S concentration in the B21h horizon. Sulfate concentrations were a small proportion (<15%) of total S in B horizons. Organic S was dominant (93% of total S) in all horizons. Carbon-bonded S and ester sulfate were 74% and 18% of total S, respectively. Microbial biomass was greatest in the O1 horizon of both hardwood and conifer solums (59 and 70 mg biomass C - 100g dry mass, respectively). The B21h horizon contained the greatest biomass in the mineral soil. This research demonstrated the importance of organic S in forest soils and indicated that understanding soil transformations of this S was a major factor in assessing the impact of atmospheric S deposition.

Publications: 81/03 to 83/02
LANDERS, D.H., DAVID, M.B., and MITCHELL, M.J. 1983. Analysis of Organic and Inorganic Sulfur Constituents in Sediments, Soils and Water. Intern. J. Environ. Anal. Chem. 14:245-256.

01.074
ACID PRECIPITATION RESEARCH

CRIS0089959

BATEMAN D F; Agricultural Research Service; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: NC09044 Project Type: SPECIAL GRANT
 Agency ID: CSRS Period: 15 APR 83 to 31 JUL 84

Objectives: Determine the nature and magnitude of effects of atmospheric acid deposition on terrestrial ecosystems with primary emphasis on major agricultural crops of the United States.

Approach: Proposals will be solicited from the agricultural research community to study the impact of acidic and acidifying substances, from the atmosphere, on major agricultural crops. Greenhouse, field and laboratory investigations will be employed. Measurements will be made of plant response to variable doses of acidity including changes in physiological activity and in quality and quantity of biomass and crop yield. Ambient amounts of pollutant/nutrient deposition, both wet and dry, will be the primary focus for experimentation. Effects will be quantified relative to common agricultural practices.

Progress: 84/01 to 84/12. Ten projects are underway with the overall objective of improving understanding of the beneficial and/or detrimental effects of acidic and acidifying substances from the atmosphere on agricultural crops. Six institutions have received subcontracts: NCSU, University of Illinois, University of California-Riverside, University of Tennessee, VPI&SU, and Ohio University. Specific research activities include the epidemiology of major crops when impacted by acid deposition, interaction between ozone and acid deposition, impact of acid fog on major California crops, and extensive screening of agricultural species for sensitivity to acidic deposition. The specific projects funded all fall within the research priorities identified by the National Atmospheric Deposition (IR-7) - Technical Committee.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

01.075
IMPACTS OF FOREST LAND USE ON WATER QUALITY IN NORTH CAROLINA

CRIS0080035

GREGORY J D; Forestry; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: NC03691 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 85

Objectives: Develop a physiographic system of classifying forest habitat regions in North Carolina that will be applicable to both site quality and hydrologic characteristics, conduct a problem analysis of specific data needs for natural water quality and for pollution resulting from silvicultural activities, and implement priority field studies identified in the analysis.

Approach: Tentative forest habitat regions have been delineated on imagery and will be further refined by incorporating geologic, soils, hydrologic, and climatic data. Regions will be ranked according to potential for water pollution related to forestry activities and prioritized for further study. An extensive problem analysis will be utilized to define and prioritize research needs in the area of forestry and water quality. Field studies will be designed and implemented to address the highest priority questions identified.

Progress: 84/01 to 84/12. This project was extended to September 1985 to allow completion of a study of the relationship of turbidity to suspended sediment concentration in small Piedmont streams. Grab samples have been collected during the year and preliminary regressions have failed to show a strong correlation between sediment concentration and turbidity. A runoff measurement station has been installed with a stage actuated water sampler in order to collect a number of samples across each stormflow hydrograph. Planning is underway for a new project on forest water management in the lower Coastal Plain. Preliminary field work has been initiated for two studies in cooperation with the International Paper Company and the North Carolina Forest Service. The first experiment will determine the influence of drainage ditch spacing and water control on water table behavior and tree growth. The second study is a long-term paired watershed experiment to determine the hydrologic impacts of drainage. GRADUATE STUDENTS = 2.

Publications: 84/01 to 84/12

- BLANK, G. B., DILLON, P. J. and GREGORY, J. D. 1984. Hydrology. pp. 427-433. In: The Acidic Deposition Phenomenon and Its Effects: Vol. II. Effects Sciences. Critical Assessment Review Papers. USEPA.
 GREGORY, J. D. 1984. Forestry-processing and field water management. Sec. IIC. pp. 39-46. In: Assessment of available water resources, water issues and future demands. Report of the Water Conservation and Utilization Task Force.
 GREGORY, J. D. 1984. Water management for silviculture in the lower Coastal Plain. Paper presented to Annual Conference of the National Council on Air and Stream Improvement for the Pulp and Paper Industry. Atlanta, GA, May 30, 1984.
 GREGORY, J. D. 1984. Availability and demands for water in forestry. N.C. Chapter, SCSA, Annual Meeting. June 15- 16, 1984. Raleigh, NC.

01.076
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

CRIS0089835

BRUCK R I; COWLING E B; Plant Pathology; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: NC01607 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: 1) To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. 2) To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands and soils; b) the health and productivity of domestic animals, wildlife, and fish; c) the chemical composition of surface and groundwaters; and d) atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: A. Samples of precipitation and dry particulate matter will be collected weekly at five states in NC and analyzed for SO₄, NO₃, PO₄, Cl, NH₄, K, Na, Ca, Mg, pH, total and free acidity, and electrical conductivity. B. Measurements will be made of the input of nutrients from the atmosphere to various crops and toxic effects of precipitation constituents on crop plants and forest trees.

Progress: 84/01 to 84/12. A network of 7 NADP monitoring stations strategically placed in the Coastal Plain, Piedmont and Mountains of N.C. continued weekly monitoring to measure the chemistry of wet and dry atmospheric deposition. Plans were initiated to install an 8th station on the summit of Mt. Mitchell, N.C. to assess deposition on the highest point in the eastern U.S. Research programs investigating the effects of simulated acidified precipitation on 5 agronomic crop plant-pathosystems continued. Preliminary results indicate that the rate of epidemic progression of Potato Late Blight and Peanut Leaf Spot can be reduced by application of simulated rain below pH 4.0; while increases in the rate of disease were observed in Soybean Brown Spot and Alfalfa Leaf Spot. Studies correlating the incidence and forms of anthropogenic pollution on high altitude boreal montane forest decline were initiated. It was observed that declining trees were more abundant at high west facing aspects where higher loading of soil and tissue lead, cadmium, copper, and zinc were observed. The incidence and vigor of red spruce and Fraser fir ectomycorrhizae was also reduced in affected areas. Although these preliminary data are only correlative, it appears that atmospheric deposition may play a significant role in stressing these ecosystems.

Publications: 84/01 to 84/12

- BRUCK, R.I. 1984. Boreal montane forest decline. Perspectives of a Forest Pathologist. Annual Meeting of TAPPI. TAPPI Journal 37:159-163.
- BRUCK, R.I., ROBARGE, W.P., REYNOLDS, K.M., REBERTUS, R., PYE, J., and HALEY, K. 1984. Observations of boreal montane decline in the southern Appalachian Mountains--Soil and vegetation studies. U.S. EPA, NADAP Peer Review Document.
- MEIER, S., SHAFER, S., BRUCK, R.I., and GRAND, L.F. 1984. Effects of simulated acid rain on ectomycorrhizae of loblolly pine. Proc. Southwide Forest Disease Workshop 10:40.

BRUCK, R.I., and MEIER, S. 1984. Boreal montane forest decline and dieback: Why and Who's Next. Proc. Southwide Forest Disease Workshop 10:37.

01.077

CRISO094165

ACIDIC DEPOSITION AND ITS INFLUENCE ON MOBILIZATION OF ALUMINUM IN ACID SOILS

ROBARGE W P; Soil Science; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
Proj. No.: NC03898 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 89

Objectives: Develop and use analytical techniques to assess effects of acidic deposition on soil ecosystems with emphasis on: rate of Al release as a function of acidic input; sources of Al that react rapidly with acidic inputs; and suitability of radioisotopes as tracers for Al reactions in soils.

Approach: Pressure membrane filters will be used to measure rate of Al release as a function of acidic input. Labile and total Al in leachates will be determined with 8-hydroxyquinoline reagent. Ion activities will be calculated using computerized chemical models. A combination of soil titrations at constant pH and extracting solutions will be used to quantify sources of Al that react rapidly with acidic input. Batch equilibrations and leaching studies with radioisotopes of Sc, La and Ga will be used to test their suitability as tracers for Al reactions in soils.

01.078

CRISO074748

CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON AGRICULTURE, FORESTRY, SURFACE, WATERS, AND MATERIALS

WEIDENSAUL T C; Environmental Studies Lab; Ohio Agric Res and Devlp Center, Wooster, OHIO 44691.
Proj. No.: OH000627 Project Type: HATCH
Agency ID: CSRS Period: 02 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America and assess the effects of atmospheric deposition on the following: productivity of agricultural crops, forest trees, rangelands, wetlands, and soils and on the chemical composition of surface and ground waters.

Approach: Wet and dry atmospheric deposition samples are collected at weekly and bi-monthly intervals, respectively and will be analyzed for various components. Spatial and temporal trends in deposition will be determined via data analyses of stored information from around the U.S. Studies will be conducted to determine the influence of natural soil solution and atmospheric acidification as well as field and laboratory studies to assess the impacts of

atmospheric acidity on forest productivity and soil microorganism activity. Leachability of soils from Ohio, PA., NY, and Ontario will be studied re exposure to acid gases and simulated acidic deposition.

Progress: 84/01 to 84/12. Wet and dry deposition continue to be monitored at Caldwell and Wooster, Ohio. The total wet deposition of monitored materials at the two locations between Jan 1 and Dec 31, 1983 is recorded below. pH values are not normalized for total rainfall re hydrogen ion deposition.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

01.079 CRISO089297
SOIL, SURFACE WATER, AND PRECIPITATION ACIDITY AND EFFECTS ON PLANTS, SOILS, AND MICROORGANISMS

WEIDENSAUL T C; DICK W A; TUOVINEN O H; Lab For Environmental Studies; Ohio Agric Res and Devlp Center, Wooster, OHIO 44691.
Proj. No.: OH000332-SS Project Type: STATE
Agency ID: SAES Period: 01 SEP 82 to 31 AUG 85

Objectives: Determine forms and amounts of sulfur volatilization from soil systems as affected by various climatic variables and natural phenomena in green plants and microorganisms. Evaluate the sulfur budget in terms of intensity and fertilizer application. Compare element leaching responses in forest soils as affected by atmospheric sulfur dioxide and acidified precipitation. Determine forest tree growth responses to air pollutant stresses emphasizing acidified precipitation. Evaluate effects of acid precipitation and gaseous sulfur dioxide on forest tree seedling performance and on the activity of microorganisms. Determine effects of sulfur-oxidizing and-reducing bacteria on changes in the quality of leachate and runoff water. Determine the sulfate and nitrate status of soil in Ohio.

Approach: Studies will be conducted under controlled acidity amendment regimes and gaseous pollutant exposures. Field studies using lysimeters and ambient SO₂(32) monitoring will evaluate sulfur budgets, transformation, and emissions from agricultural soils. Tree-ring analyses will be used to evaluate atmospheric stresses on forest trees.

Progress: 84/01 to 84/12. Precipitation chemistry monitoring data continue to be collected at two sites in Ohio. Two strains of *Thiobacillus ferrooxidans* were able to tolerate A1 at 0.25 M concentration. The effects of several sulfoxyanions was investigated with growing cultures of *Nitrobacter winogradskyi*. Complete growth inhibition occurred at fairly low concentrations of persulfate, tetrathionate, dithionite, metabisulfite, and trithionate. Aluminum, Ni, and molybdate ions at 5mM decreased O₂ uptake by *Nitrobacter agilis*. The largest flux of SO₄(4)-S output from lysimeter plots occurred between October and December. Both tillage and S fertilizer

addition affected S flux in the soil. Sulfur outputs are greater than can be attributed to wet deposition. In soil columns, Ca, Mg, and K are generally leached first by simulated rain. There is no obvious trend that clearly relates basic cation leaching to treatment acidity. The most acidic rain solutions were not associated with higher amounts of Zn, Mn, Fe, Ca, Mg, Al, K, and Na in the leachate. Cation leaching peaked when soil solution acidity was greatest, suggesting that total acidity is associated with element leaching. Response function analyses are being made for trees studied in the FORAST Project. Core collections have been made for X-ray densitometry determinations. The importance of climatic variables in tree growth is assessed as well as effects due to air pollutants. The influence of acidic rain on the development of Southern Corn Leaf Blight is being studied.

Publications: 84/01 to 84/12
MORRA, M.J. and DICK, W.A. 1984. Production of thiocysteine (sulfide) in upland amended soils. *Agron. Abstracts*, 1984.
MCCLLENAHEN, J.R. 1985. Tree-ring response of white oak to climate and air pollution near the Ohio River Valley. *J. Environ. Qual.* (In Press).

01.080 CRISO093520
THE ECONOMICS OF RESIDUALS: SOIL EROSION AND SEDIMENT; SLUDGE AND SOLID WASTE; ACID RAIN

FORSTER D L; SOUTHGATE D JR; HITZHUEN F J; Agri Economics & Rural Sociol; Ohio State University, Columbus, OHIO 43210.
Proj. No.: OH000780 Project Type: HATCH
Agency ID: CSRS Period: 01 AUG 84 to 31 OCT 87

Objectives: Explore the economics of technically viable options for controlling soil erosion and sediment deposition in the East Fork of the Little Miami River Basin (Southwestern Ohio) and the Valdesia Watershed (Dominican Republic), recycling sludge, metals and other valuable residuals, and reducing both source emissions and receptor damage from acid rain.

Approach: The analysis of soil erosion and sediment control requires estimates of costs and benefits for three groups - farmers, downstream water users, and future generations of producers. Also, options for controlling erosion may impact regional economics, and these will be investigated through regional input-output models. Analysis of recycling sludge and other residuals requires estimates of benefits and costs. The focus will be economics of size in composting plants and the effect of composting on wastewater treatment costs. Cost effectiveness estimates will be made for options to control acid rain. Also, institutional mechanisms for dealing with the spillover aspects of acid rain will be inventoried.

Progress: 84/08 to 84/12. D. Southgate was one of two principal investigators on a study of the feasibility of using heat generated at the Piketon, Ohio uranium enrichment facility

to heat a greenhouse complex. Five faculty members and three graduate students participated in the study, which was funded by DDE. In addition to the final report, manuscripts based on project research have been submitted to J. Am. Soc. Hort. Sci. and J. Northeastern Ag. Econ. Council. Articles describing research on third world soil erosion problems written by Doug Southgate, Fred Hitzhusen, and others have appeared or will shortly appear in Am. J. Ag. Econ., Land Econ., and Water International. Papers on the same topic were presented at the East-West Center and at annual meetings of the Am. Ag. Econ. Assoc., and the Soil Conservation Society of America. Forster's work in the area of soil erosion and sediment has resulted in two manuscripts being accepted for publication. One reported the results of six years of work in the Lake Erie Basin. It describes a program to reduce pollutant loads to Lake Erie. The other manuscript reports estimates of off-farm costs of soil erosion in northwestern Ohio.

Publications: 84/08 to 84/12

FDRSTER, D.L. and ABRAHAM, G. 1985. "Sediment deposits in drainage ditches: a cropland externality," Journal of Soil and Water Conservation.

FDRSTER, D.L., LOGAN, T.J., YAKSICH, S.M. and ADAMS, J.R. 1985. An accelerated implementation program for reducing diffuse source phosphorus load to Lake Erie. Journal of Soil and Water Conservation.

01.081 CRIS0087736
ECONOMICS OF NATURAL RESOURCE UTILIZATION
POLICY WITH EMPHASIS ON PACIFIC NORTHWEST LAND
& WATER

MCCARL B A; DBERMILLER F W; Agri & Resource Economics; Oregon State University, Corvallis, OREGON 97331.
 Proj. No.: DRE00121 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 82 to 30 JUN 87

Objectives: To improve the quality of policy decisions relating to the use of Pacific Northwest (PNW) land and water resources. Analyze trends in the usage of PNW resources, particularly by agriculture, forestry, and fisheries; Examine the influence of policy on these trends; Identify the effects of changes in policy on economic efficiency and distributive equity; Identify key factors, constraints, and conflicts which influence natural resource supported economic development in the PNW; Analyze issues of current and/or foreseeable future interest providing information on the consequence of potential policies.

Approach: Analytical models will be developed for examination of PNW resource policy questions. These models will be used to predict effects of resource policy. The models and model development process will also facilitate understanding and analysis of policy options.

Progress: 84/01 to 84/12. New irrigation development above Grand Coulee Dam on the Columbia was found to be as costly as \$200 per

acre per year electricity consumers and society. However, this cost was found to be greatly reduced if irrigators were allowed to a) develop lands further downstream; b) divert water only in noncritical flow years; or c) pay the full cost of pumping. The current system for charging for grazing fees was found to be inferior to one based on the private land lease rate in preventing future discrepancies. Further, it was found that the total social value of grazing lands could only be increased by lowering fees not by increasing them. The increases basically transfer money from ranchers to the public. The changes in the Canadian exchange rate between 1975 and now were found to be important determinants in the increasing share that Canadian lumber constitutes of the U.S. lumber market. U.S. agriculture was found to be the most affected sector by ozone air pollution. A 10% reduction in ambient ozone was predicted to have a \$0.76 billion cost to society while 25% and 40% reductions were found to exhibit \$1.94 billion and \$2.86 billion cost increases, respectively. A 25% increase in ozone would lead to a predicted \$2.36 billion cost in ozone. Changes in the location of export elevators was not found to be an efficiency increasing alteration. Ocean shipping rates were found to be a significant factor in determining grain shipping patterns.

Publications: 84/01 to 84/12

NELSDN, C.H. and MCCARL, B.A. Including Imperfect Competition in Spatial Equilibrium Models. Canadian Journal of Agricultural Economics 32(1)1984:55-70.

ALI, I., BARNETT, D., KENNINGTON, J., MCCARL, B., PATTY, B., SHETTY, B., and WDN, P. Multicommodity Network Problems: Applications and Computations. IIE Transactions, June 1984:127-134.

BARNETT, D., BINKLEY, J. and MCCARL, B. Port Elevator Capacity and National and World Grain Shipments. Western Journal of Agricultural Economics 9(1984):77-89.

MCCARL, B. and HAYNES, R. Exchange Rates and Softwood Lumber Trade. Journal of Forestry 1984.

MCCARL, B., ARTHUR, J., KENNINGTON, J. and POLITO, J. SEBEND: A Computer Algorithm for the Solution of Symmetric Multicommodity Spatial Equilibrium Problems Utilizing Benders Decomposition. DSU Special Report 708, 1984.

01.082 CRIS0095439
H+ BUDGETS AND ECOSYSTEM ACIDIFICATION: CASE
STUDIES OF RED ALDER AND DOUGLAS-FIR ECOSYSTEMS

SDLLINS P; BINKLEY D E; Forest Science; Oregon State University, Corvallis, OREGON 97331.
 Proj. No.: DRE-FS-392-S Project Type: STATE
 Agency ID: DCI Period: 01 FEB 85 to 31 JUL 87

Objectives: To construct H budgets for pairs of pure conifer and nitrogen-fixing red alder/conifer stands at two locations in the Pacific Northwest.

Approach: One location H+ highly fertile and soil acidity has increased under alder. The other location is less fertile, and no change in soil acidity can be detected. The importance of our project lies in two directions. First, the enhancement of soil fertility by N-fixing alder may in part be offset by "natural" acidification and leaching losses of cation nutrients. Second, the internal H generating and absorbing processes of forest ecosystems are major variables involved in determining the effects of atmospheric inputs of H. Our research would serve to elucidate the mechanisms regulating soil acidification beneath alder and also provide a framework for comparing long-term natural acidification with the effects of increased H inputs from acid precipitation.0.

from 4,660 kg/ha to 11,200 kg/ha. Rainfall amount and distribution have greatly affected yields. Sampling for rainfall of S content will not be continued on a monthly routine basis during 1985 for the 16 sites throughout the state since the S. C. Dept. of Health and Environmental Control is no longer a cooperator. Sampling will continue at Clemson and tentative plans are to continue sampling at Florence and the Simpson Station. Total S content of rainfall varies slightly from year to year and is closely related to amount of rainfall.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

01.083 CRIS0084372
SULFUR AND NITROGEN COMPONENTS OF PRECIPITATION AND EFFECTS ON SOIL FERTILITY AND PLANT NUTRITION

CRADDOCK G R; PITNER J B; Agronomy & Soils; Clemson University, Clemson, SOUTH CAROLINA 29631.
Proj. No.: SC00501 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 81 to 31 DEC 85

Objectives: Determine the contribution of sulfur in precipitation and partiturfur in soils. Determine the response of corn (Zea mays) to different rates of sulfur applied at varying rates of nitrogen to a Typic Paleudult. Determine the contribution of nitrogen (NH(4)+NO(3)) and sulfates in atmospheric deposition to plant nutrition and quantify their potential effects on fertilizer sulfur and nitrogen needs for corn.

Approach: Corn fields representing the principle South Carolina soil series will be selected and the sulfur content of soil and corn leaf monitored for six years. Concurrently on the same fields, sulfur in the ambient atmosphere and that in precipitation will be monitored monthly to ascertain the trends in contribution of atmospheric sulfur to the soil and plant supply. A long term field experiment will be initiated with corn at the Pee Dee Experiment Station. The basic fertilizer will contain sulfur-free materials and will comprise one treatment - the control. Other treatments will consist of side-dress applications of gypsum to supply 9, 18, and 36 kg/ha of sulfur respectively at two rates of nitrogen. Concurrently chemical components of acid precipitation will be monitored weekly at the Pee Dee Experiment Station and at Clemson University.

Progress: 84/01 to 84/12. Final year of a 4-yr field study for response of corn (zea mays) to added S will be completed and summarized in 1985. Using treatments of 0, 9, 18, and 36 kg/ha of added S on an Arenic Palendult resulted in a significant yield (P = 0.05) of 10% only for added S for the 1981 yr (1styr). Treatments receiving no S have ranged

01.084 CRIS0090257
RELEASE OF ALUMINUM FROM SOILS BY ACID PRECIPITATION

HODGES S C; Agronomy & Soils; Clemson University, Clemson, SOUTH CAROLINA 29631.
Proj. No.: SC01050 Project Type: STATE
Agency ID: SAES Period: 01 JUL 83 to 31 AUG 85

Objectives: To ascertain the relationship of aluminum mobilization by acid precipitation with soil physiochemical factors such as pH, cation exchange capacity organic matter content and clay mineralogy. To define and verify the pathways involved in the release of Al by soils subjected to environmentally relevant concentrations of acid inputs. To identify the species and complexes of Al released by soils to percolating waters. To validate and refine existing chemical simulation models for predicting nutrient loss and aluminum mobilization from soils as a result of acid precipitation.

Approach: Sequential batch extractions and column studies will be used to examine the effects of two synthetic acid rain solutions (pH 4.0 and 3.0) on fully characterized soil horizons dominated by either organic matter, kaolinite-sesquioxides, montmorillonite, vermiculite or gibbsite. Solutions and soils (subsamples) will be analyzed for chemical and mineralogical changes relevant to the stated objectives.

Progress: 84/01 to 84/12. Using synthetic acid rain treatments of pH 4.0 and 3.0, we have found major differences in the processes leading to aluminum release for different soils of the Southeast. At pH 4.0, base exchange initially dominated the buffering reactions in soil, and very little aluminum is released from mineral soil horizons. After 15 sequential treatments, aluminum levels were slowly increasing in the mineral soils. Soil horizons with high organic matter contents released aluminum readily at either treatment pH. At the pH 3.0 treatment level, reacted protons exceeded the exchange capacity of the mineral soils within three treatments, at which point aluminum released exceeded protons reacted, indicating breakdown of clay minerals. Organic matter seemed to offer little additional buffering at this pH level, since very similar amounts of aluminum were released in both

treatments for the first two extractions. The aluminum released after these extractions was, as in the mineral soils, much more dependent on the clay mineral content. In conclusion, organically bound aluminum seems to be released more readily than mineral forms, but as acidification proceeds, the bulk of the aluminum will come from mineral sources. Unmanaged soils of the Southeast have very low exchange capacities, and generally have very low base saturations. Ion exchange alone (without base tight cycling) will have little lasting effect in the buffering of these soils against long term inputs of acid.

Publications: 84/01 to 84/12

HODGES, S.C. and FRANTZ, W.C. 1984.

Determination of "active" aluminum A comparative study. Agron. Abstr. 1984, p. 28.

HODGES, S.C. and JOHNSON, G. 1984. Kinetics of sulfate adsorption and desorption by a Cecil soil using miscible displacement. Agron. Abstr. 1984, p. 178.

QUISENBERRY, V.L., HATFIELD, M.W. and HODGES, S.C. 1984. Solution and surface diffusion of sulfate in a forested Cecil soil. Agron. Abstr. 1984, p. 180.

average pH of 4.42 (as rain) was collected. Total wet deposition for H, SO₄-S, NO₃-N, and NH₄-N was 0.63, 11.08, 3.99, and 2.92 kg/ha. The sample pH ranged from 3.75 to 5.22, with the lower values occurring primarily in the months from April to August. During the month of July alone, 36.4% of the H, 28.9% of the SO₄-S, and 24.2% of the NO₃-N was collected in 21.3% of the annual precipitation. The pH values were consistently higher in the months of September to January. These findings indicate that the amount of acid deposited in the past year would require addition of only 32 kg/ha of CaCO₃ for neutralization in farmlands of this region. At the same time, 6.9 kg/ha of N and 11.1 kg/ha of S were added, mostly during the growing season. While acid deposition may effect the chemistry of unmanaged soils over time, it remains clear that it should have little negative influence on soils of well managed farmland.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

01.085 CRIS0088965
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

HODGES S C; CRADDOCK G R; Agronomy & Soils; Clemson University, Clemson, **SOUTH CAROLINA** 29631.

Proj. No.: SC01034 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America; assess the effects of atmospheric deposition on productivity of agricultural crops, forest trees, rangelands, wetlands and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery and structure.

Approach: Major attention will be given to the collection, quantitative characterization, and chemical analysis of the water soluble and water insoluble substances contained in precipitation, airborne gases, and both fine aerosol and coarse particulate matter. The chemical substances of special interest include nutrient cations and anions, especially H, NH₄, SO₄ and NO₃. Studies will consider the effects of acid deposition on yield, quality, fertilizer needs and other economically important variables of crop production.

Progress: 84/01 to 84/12. Weekly collections of wet precipitation using an Aerochem Metrics sampler yielded 42 analyzable samples for the period from 23 August, 1983 to 14 August, 1984. A total of 168.3 cm of precipitation, with an

01.086 CRIS0079170
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

JONES U S; Agronomy & Soils; Clemson University, Clemson, **SOUTH CAROLINA** 29631.
 Proj. No.: SC00382 Project Type: HATCH
 Agency ID: CSRS Period: 01 MAY 79 to 30 SEP 82

Objectives: Determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the U. S. Determine the effects of atmospheric deposition on plants and soils.

Approach: Samples of precipitation and dry particulate matter will be collected weekly at Clemson, SC and analyzed for SO₄(4), NO₃(3), PO₄(4), Cl, NH₄(4), K, Na, Ca, Mg, pH, total and free acidity, and electrical conductivity. Measurements will be made of the input of nutrients from the atmosphere to various crops and toxic effects of precipitation constituents on plants and soils.

Progress: 82/10 to 82/12. Particulates and precipitation continue to be collected weekly at Clemson using an Aerochem metric wet/dry precipitation collector. Chemical analyses of the atmospheric deposition is continuing. Variations in total annual atmospheric S and N deposition are well correlated with total annual precipitation in the Southeastern United States.

Publications: 82/10 to 82/12

NO PUBLICATIONS REPORTED THIS PERIOD.

01.087 CRIS0091494
**THE IMPACT OF ACID PRECIPITATION ON PIEDMONT
 FOREST SOILS**

VAN LEAR D H; Forestry; Clemson University,
 Clemson, SOUTH CAROLINA 29631.
 Proj. No.: SCZ01806-FR Project Type: STATE
 Agency ID: OCI Period: 01 AUG 82 to 30 JUN 85

Objectives: To determine the importance of anthropogenic inputs of acidity, natural internal production of acidity, and tree harvesting techniques to nutrient losses from a Piedmont forest soil. To evaluate present and potential future adequacy of soil nutrients for sustained forest productivity based on measurement of present nutrient pools in forests, nutrient status of soils, nutrient losses by acid deposition, natural internal processes, and tree harvesting.

Approach: Precipitation and throughfall will be collected by 10 open-bucket collectors in and adjacent to a 42-year-old loblolly pine plantation and two recently clearcut watersheds. Contents of all containers will be composited after each collection for chemical analysis. Lysimeters at two depths at 5 locations will sample the soil solution on a monthly basis. Nutrient loss from each watershed is determined by samples collected weekly below in H-flume equipped with a .61 m Coshocton wheel. Nutrient content of both overstory and understory vegetation as well as the forest floor and mineral soil to a 60 cm. depth has been completed. The effect of acid precipitation on cation losses will be determined by measuring cations in solution.

Progress: 84/01 to 84/12. Objectives of this project are to evaluate effects of acidic deposition, natural leaching, and timber harvest on cation losses from forest sites. Nutrient dynamics have been monitored on a mature loblolly pine stand, a conventionally harvested stand, and a whole-tree harvested stand. During 1984, precipitation, throughfall, stormflow, and soil solution samples were collected, analyzed, and added to the data base previously established. Hydrologic export of cations via stormflow and leaching was greater than that removed in either harvest method. Preliminary results indicate that the majority of the basic cations leached from these sites is due to anthropogenic sources of anions. Sulfate anions account for 40-70 percent of total cation leaching.

Publications: 84/01 to 84/12
 ND PUBLICATIONS REPORTED THIS PERIOD.

01.088 CRIS0079704
**AVAILABILITY OF SECONDARY NUTRIENTS IN
 TENNESSEE SOILS**

WOLT J D; Plant & Soil Sciences; University of
 Tennessee, Knoxville, TENNESSEE 37916.
 Proj. No.: TEN00565 Project Type: HATCH
 Agency ID: CSRS Period: 01 DCT 79 to 30 SEP 85

Objectives: Determine the sulfur balance in selected Tennessee soils and its relation to crop growth and nutrient content. Determine the effect of selected agronomic practices on the Ca and Mg availability of some Tennessee soils. Determine soil-solution cation activity ratios in relation to exchangeable and extractable Ca and Mg and crop yield, quality, and composition.

Approach: Amount, distribution, and S content of rainwater, fertilizer S and inputs, available S of soil profiles, and S uptake by crops will be measured over time in order to determine S balance of selected soils throughout Tennessee. Field experiments will be performed to determine the influence of soil type and rates and sources of lime upon Ca and Mg availability as assessed by exchangeable Ca and Mg, extractable Ca and Mg, and crop yield and composition. Field and greenhouse experiments will be conducted to determine suitable parameters for expression of Ca and Mg availability. Measurements to be taken will include exchangeable and extractable cations, composition of displaced soil solutions, and crop yield, quality, and composition.

Progress: 84/01 to 84/12. Twenty-eight experiments on 16 soil types throughout Tennessee have shown no response of soybean to Mg (16 to 65 kg/ha) or S (25 to 102 kg/ha) fertilization when soil test S and Mg were >5 and >30 mg/kg, respectively. No-till soybean grown on a Glossaquic Fragiudalf have not responded to variation in CA:Mg ratio of applied lime in three years of experimentation. Soybean cultivars demonstrated considerable variation in foliar nutrient content as a function of Ca:Mg ratio of applied lime. Variation in Ca:Mg ratio of lime applied to a Typic Hapludult initially low in soil test Ca and Mg (174 and 4 mg/kg, respectively) influenced yield, fruit quality, and nutrient content of tomato. Crop response to Ca and Mg was differentially influenced by a hot, dry versus a cool, moist growing season. Fall application of S (224 kg/ha/yr) to fescue sod grown on a Typic Paleudult consistently increased S concentration of spring-harvested forage over six years of application, but did not influence crop yield or total S removal. Both yield and S removal were increased with N topdressing (67 kg/ha/yr) in the late winter or early spring. Over 35% of applied S (448 kg/ha) was retained in the upper one meter of the soil profile. Sulfur fertilization (17 or 34 kg/ha) did not affect corn yield or S content in nine-location-years of experimentation on soils testing >7 kg S/ha. Wet/dry S deposition (16 kg/ha/yr) contributed nearly 3 times more S to the crop-soil system than was removed in harvested grain.

Publications: 84/01 to 84/12
 BAUMAN, M.B. and WOLT, J.D. 1984. Corn response to sulfur in Tennessee. Tenn. Farm and Home Sci. 131:5-7.
 WOLFE, M.H. 1984. The influence of stemflow on the distribution of sulfate-S around the base of two tree species. M.S. Thesis, University of Tennessee, Knoxville.

01.089 CRIS0076369
**SOIL FERTILITY, MANAGEMENT, AND PLANT NUTRITION
 FOR FORAGE AND HORTICULTURAL CROP PRODUCTION IN
 EAST TEXAS**

HABY V A; Research & Extension Center; Texas
 A&M University, Overton, TEXAS 75684.
 Proj. No.: TEX06320 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 83 to 30 JUN 88

Objectives: Determine the influence of varying levels of soil acidity on the availability of soil and applied fertilizer nutrients for roses and warm and cool season grasses and legumes. Evaluate the efficiency of applied N and that fixed by leguminous plants for small grains and warm season grass production. Evaluate the influence of K fertilizers on disease reduction in small grains and Coastal bermudagrass. Determine the soil fertility and fertilizer requirements of blueberries and peaches under East Texas conditions. Determine the effect of acid rain on East Texas soils and crops. Relate crop responses from various plant nutrient applications to the soil test level of those nutrients in order to improve the predictability of the soil test for fertilizer needs.

Approach: Field studies on bench mark soils of East Texas will be used to evaluate the responses of soils and crops to fertilizer nutrients and limestone. Greenhouse research will support the field studies. Soil and plant analyses in the laboratory will help evaluate field and greenhouse experiment responses. Data will be evaluated by appropriate statistical analyses.

Progress: 84/01 to 84/12. Ryegrass yield responses to limestone rates of 0, 672, and 3810 kg/ha were 3119, 5063, and 6020 kg/ha, respectively. Yields increased from 4120 to 5629 kg/ha as P rate increased from 0 to 240 kg/ha, respectively. Winter wheat grain yield increased from 1463 to 4016 kg/ha with N rate increments from 0 to 224 kg/ha, respectively, but yield differences due to the N sources ammonium nitrate, urea, and urea phosphate were negligible. Prior year growth of subterranean clover contributed the equivalent of 70 kg N/ha to the wheat. Winter wheat grain yields were similar for KCl and K(2)SO(4) potassium sources. Yield response to K rate increases was not statistically significant. A versatile, three-point hitch, tractor-mounted applicator was designed and constructed to dispense fluid fertilizers from containers pressurized by a tractor-mounted and powered pressure system. This applicator is used to evaluate dribble band spacings, methods of application, rates, and combinations of fluid fertilizers applied to Coastal bermudagrass. A severe summer drought restricted growth but grass yield from the three harvests was significantly increased from 11,500 to 15,928 kg/ha as N rate increased from 45 to 135 kg/ha at site one, and from 8064 to 10,080 at site two which is a less responsive soil. Banded urea-ammonium nitrate at spacings of 18, 36, 53, and 71 cm between bands, and method of application had no significant effect on grass yield. Nitrogen source comparisons yielded mixed results between both sites.

Publications: 84/01 to 84/12

- NELSON, L.R., HABY, V.A., BATEMAN, C. and KREJSA B. 1984. Accumulation of Al, Ca, Mg, Mn, K and P in annual ryegrass due to soil flooding. American Society of Agronomy Abstracts.
 BRANDT, J.E., HONS, F.M. and HABY, V.A. 1984. The effect of nitrogen management on the yield and nitrogen uptake efficiency of soft red winter wheat. American Society of Agronomy abstracts.
 HABY, V.A., DAVIS, J.V. and SMITH, K.L. 1984. A versatile fluid fertilizer applicator for field research. American Society of Agronomy Abstracts.

01.090 CRIS0074177
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
 ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
 MATERIALS**

WOOLDRIDGE G L; Soil Science & Biometeorology;
 Utah State University, Logan, UTAH 84322.
 Proj. No.: UTA00414 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the productivity of agricultural crops and soils.

Approach: This objective will be achieved by installation and maintenance of a wet-dry deposition collector on the Utah State University campus, as a part of the NC-141/NADP atmospheric chemical deposition network. Analysis of the data from the network will indicate spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in wet and dry deposition. This objective will be approached by cooperative sampling of soil in regions indicated in the analyses stated in Objective 1, where deposition of elements potentially toxic to agricultural crops may occur. If such sampling indicates that toxicity is developing, greenhouse studies using that soil will be initiated in a cooperative program.

Progress: 84/01 to 84/12. Atmospheric wet deposition measurements were completed on a once-a-week basis at the WUT01 deposition site 7 miles southwest of Logan, Utah throughout the year 1984. The pH and electrical conductivity of each sample were measured at the Utah State University laboratory prior to the Central Analytical Laboratory for uniform analyses conforming to the National Atmospheric Deposition Program standards. Initial results of WUT01 sample analyses indicate that (1) CAL measurements of pH generally range from 6.0 to 6.6, with extreme values of 5.0 and 7.3; (2) weekly averages of NO3 ion concentrations are usually 50% to 100% of SO4, but on occasion have exceeded the SO4 ion concentrations. It appears that the WUT01 site would be suitable for use as a "control" site for effects research comparisons.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

01.091 CRIS0079097
**EFFECTS OF ACCUMULATION OF HEAVY METALS ON
FOREST & ALPINE ECOSYSTEM IN THE GREEN
MOUNTAINS OF VERMONT**

VOGELMANN H W; Botany; University of Vermont,
Burlington, VERMONT 05405.
Proj. No.: VTO0319 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 84

Objectives: Determine extent and rate of accumulation of selected heavy metals in the soils and plants of upper elevation in the Green Mountains. Evaluate effects on growth, development, vigor and distribution of plants in the upper mountain forest zones.

Approach: Establish base line data on heavy metal content in plants and soils collected 1964-68 at 2000 ft on Camel's Hump Mountain. Compare with data on recent collections. Collect seeds and seedlings of native plants. Stress test specimens with heavy metals (Pb, CU, Zn, Al) to determine species tolerance, and effects during germination and seedling development. Determine metal toxicity on fungi common in mycorrhizal associations with forest tree species using Armillaria as model.

Progress: 83/01 to 83/12. A resurvey of the forests on Camel's Hump mountain in northern Vermont indicated that since 1965 there has been a dramatic decline in above ground forest biomass. The boreal zone above 850m declined 41 percent during this period while the hardwood zone, from 550m to 730m, dropped 19 percent. All tree species except yellow birch declined in biomass. Highly significant declines in seedlings and saplings were recorded for sugar maple, beech, red spruce, and mountain maple. Analysis of tree cores indicated that growth reductions began in the late 1950's and early 1960's. Detailed chemical analysis on a 100-year-old core of sugar maple and a 200-year-old core of red spruce indicated a change in wood chemistry began about the time of growth decline. Aluminum concentrations in wood of both species doubled since 1950 to current concentrations of 25 ug/g. As, Ge, and V elements strongly associated with coal or oil combustion, increased in the early 1900's to 8, 24, and 40 ug/g, respectively, in the most recently formed wood. Mg concentrations in both species showed a strong negative trend, while concentrations of other nutrient cations did not demonstrate any pronounced direction.

Publications: 83/01 to 83/12
VOGELMANN, H.W. 1983. Acid rain: are our forests in danger? Outdoor America, 48:13-15.

SCHERBATSKOY, T., and BLISS, M. 1984. Occurrence of acidic rain and cloud water in high elevation ecosystems in the Green Mountains of Vermont. In: Proc. Air Poll. Cont. Assoc. Speciality Conf. on the meteorology of acidic deposition.

SCHERBATSKOY, T. 1983. Results of current investigations on the impacts of acid rain on Vermont forests. In: Proc. New Eng. Soc. of Amer. foresters 63rd annu. winter mtg., 1983. (ed.) Hannah, P.

01.092 CRIS0044490
**SOIL AND WATER MANAGEMENT SYSTEMS FOR
RECLAMATION OF DISTURBED LAND IN APPALACHIA**

BENNETT O L; BOYER D G; JONES J N; USDA
Agricultural Research Service, Beckley, WEST
VIRGINIA 25801.
Proj. No.: 1932-20770-002-00D

Project Type: INHOUSE
Agency ID: ARS Period: 12 MAY 78 to 30 SEP 83

Objectives: Develop reclamation and management practices for strip mines and other disturbedlands to optimize desirable plant growth under stress environments and minimize environmental damage, especially to the hydrology and water quality of the area.

Approach: Work will involve laboratory, growth chamber, greenhouse, and field studies to evaluate chemical, physical, and environmental factors that limit stabilization and reclamation of disturbed land areas. Specific investigative parameters will include hydrologic factors, water quality, plant growth and composition, microbiological populations and changes with treatments, fertilization and liming comparisons, use of domestic and industrial waste materials to reduce acidity and improve soil condition, and ways to avoid toxic trace elements in such wastes.

Progress: 83/01 to 83/12. Performance of yearling steers grazing forages grown on reclaimed strip mined land and treated with fluidized bed combustion residue (FBCR) produced gains equal to those from animals grazing on surface mine land treated with agricultural limestone. The FBCR is a granular material resulting from burning coal in a combustion chamber along with finely ground limestone to reduce sulfur and nitrous oxide emissions which are major sources of acid rain. Data indicates that FBCR can be substituted from limestone for correcting subsoil acidity without having any detrimental effect on the grazing animal. Agricultural use of this material may provide a convenient way of disposing of the waste and providing needed plant nutrient sources for agriculture. In other studies, the effects of revegetation and management practices on water quality on reclaimed surfacemined lands are being studied. The effects of grazing and fertilization programs on effluent quality from reclaimed mine lands will improve our understanding of post mining land use and eliminate water quality problems. The topographic and microclimatic effects on the soil moisture balance of a Central Appalachian surface coal mine indicates that moisture relations can vary widely in mountainous terrain due to slope, exposure, and elevation.

Publications: 83/01 to 83/12

MENSER, H.A., WINANT, W.M., and BENNETT, O.L. 1983. Spray irrigation with landfill leachate. Biocycle, May-June 1983, pp. 22-25.

GHAZI, H.E., SINGH, R.N., KEEFER, R.F., and BENNETT, O.L. A comparison of level methods for extracting available P from mine soils treated with fly ash and rock phosphate. Presented at NE Branch Am. Soc. of Agron. Mtg.

BOYER, D.G. 1983. Relation of Surface Runoff Quality to Precipitation Quality on a Surface Coal Mine. Proceedings, National Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation, Lexington, KY. Nov. 29-Dec. 2, 1983.

KEEFER, R.F., SINGH, R.N., BENNETT, O.L., and HORVATH, D.J. 1983. Chemical composition of plants and soils from revegetated mine spoils. Presented at Symposium on Surface Mining, hydrology, Sedimentology, and Reclamation.

01.093

CRIS0044482

SOIL AND WATER MANAGEMENT SYSTEMS FOR EFFICIENT CROP PRODUCTION IN APPALACHIA

BENNETT O L; LEGG T D; PERRY H D; USDA Agricultural Research Service, Beckley, WEST VIRGINIA 25801.

Proj. No.: 1932-20780-001-00D

Project Type: INHOUSE

Agency ID: ARS Period: 12 MAY 78 to 20 JUN 83

Objectives: Develop soil, water, and plant management systems for forage, row and specialty crops on the diverse soil resource of the Appalachian region.

Approach: Laboratory, greenhouse, growth chamber, and field studies will be integrated to evaluate fertilizer amendments, use of domestic and industrial waste materials, biological nitrogen fixation, no-tillage production management systems and species for efficient use of naturally occurring plant nutrients for crop production and plant quality.

Progress: 81/05 to 83/05. Subsoil acidity can be corrected by application of large amounts of organic matter containing excessive amounts of calcium and magnesium. Organic matter proved to be an effective source of ligands for chelation and movement of calcium and magnesium into acid subsoils for replacement of high soil aluminum. Sulfur treatments can have a marked effect on efficiency of mineral utilization and protein synthesis in the plant metabolism system. Several studies have demonstrated that conservation tillage can increase yields, water use, and fertilizer use efficiency. Corn can be grown using no-tillage systems where sod regrowth is controlled by use of herbicides. Brome, orchard, and fescue grasses proved to be satisfactory for use with the "sleeping" sod no-till technique. Studies with N15 have shown a higher rate of soil nitrogen mineralization under no-till cropping systems than for conventional tillage. Composition of no-till

corn plants indicate a higher concentration of P., K., Mn., Zn., and a lower concentration of Fe., Al., Mg., and N. than in the conventionally tilled corn plants. Soil moisture under no-tillage was always higher than for tilled areas. No-till production techniques were demonstrated for potatoes, tomatoes, sweet corn, string beans, and for interseeding various legumes for reclamation of pasture areas.

Publications: 81/05 to 83/05

HERN, J.L. 1978. Elemental analysis in agriculture using inductively coupled plasma-atomic emission spectroscopy. Fifth Ann. Mtg. Federation Anal. Chem. and Spec. Soc.

HERN, J.L. and STROHL, J.H. 1978 Modified graphites for chelation and ion exchange. Anal. Chem. 50:1954.

BENNETT, O.L., STOUT, W.L., HERN, J.L. and SIDLE, R.C. 1978. Potential agricultural uses of fluidized bed combustion waste. Proc. 5th Nat. Conf. on Energy and the environment.

HERN, J.L., STOUT, W.L., SIDLE, R.C. and BENNETT, O.L. 1978. Characterization of fluidized bed combustion waste: Composition and variability as they relate to disposal on agricultural lands.

BENNETT, O.L., REID, R.L., WHITSEL, T.J., MITCHELL, D.M., STOUT, W.L., HERN, J.L. and MAY, D.L. 1982. Animal feeding trials using feed and food produced with FBCR. Proc. of 7th Intl. Conf. on FBC. Vol. 1. pp. 559-566.

01.094

CRIS0077498

CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

BOCKHEIM J G; Soil Science; University of Wisconsin, Madison, WISCONSIN 53706.

Proj. No.: WIS02372

Project Type: HATCH

Agency ID: CSRS Period: 10 OCT 77 to 30 SEP 83

Objectives: Determine spatial and temporal trends in supply of beneficial and injurious substances in precipitation and dry particulate matter deposited in various regions of the U.S.

Approach: Samples of precipitation and dry particulate matter will be collected weekly at one site in Wisconsin and analyzed for S0(4), NO(3), PO(4), DI, NH(4), Na, Ca, Mg, pH, total and free acidity, and electrical conductivity.

Progress: 83/01 to 83/12. The principal objective of this research is to collect and analyze samples of precipitation to monitor the spatial and temporal trends of beneficial and injurious substances in precipitation deposited in various regions of the United States. The Wisconsin Department of Natural Resources has established collection sites at Rhinelander, WI and Spooner, WI. All the samples are being analyzed and the data processed at the central laboratory in Urbana, IL. Data are available from the National Atmospheric Deposition Program, Fort Collins, CO, 80523. The College of Agricultural and Life Sciences at the University of Wisconsin-Madison is not

presently doing research on this project. It serves as a coordinator between the state agencies and the National Monitoring Network

Publications: 83/01 to 83/12

NO PUBLICATIONS REPORTED THIS PERIOD.

01.095 CRIS0084694
**NUTRIENT DISTRIBUTION AND CYCLING IN
 SUCCESSIONARY STANDS OF POPULUS TREMULOIDES
 MICHX., WISCONSIN**

BOCKHEIM J G; Soil Science; University of Wisconsin, Madison, **WISCONSIN** 53706.
 Proj. No.: WIS02609 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Determine biomass, nutrient cycling in successional aspen stands in northern Wisconsin for the purpose of evaluating the effects of intensive harvesting on long-term soil nutrient levels.

Approach: Using "point-sampling" techniques, a minimum of four variable-size plots will be located randomly in each of 8 aspen stands between the ages of 1 and 60 years on the Vilas loamy sand in northern Wisconsin. All trees on each plot will be harvested and biomass of the bole+bark, branches, current twigs and leaves will be determined. Evaluate nutrient distribution within various components of the ecosystem, the following elements will be analyzed N, P, K, Ca, Mg, S. The resulting nutrient budgets will be examined to see if successional aspen stands are "degrading," i.e. nutrients accumulate in the biomass at the expense of the forest floor and mineral soil, or aggrading. Nutrient fluxes as a function of stage in ecosystem development will be measured by monitoring in stands representing five critical age classes: Input by atmospheric deposition, chemical weathering, litterfall decomposition, and throughfall; and output by leaching loss.

Progress: 84/01 to 84/12. Aboveground biomass and net primary production (NPP) equations were prepared using data collected from nine plots containing trembling aspen (*Populus tremuloides* Michx.) ranging from 8 to 63 yr. in age. The Richards function $Y = A(1 - e^{-BX^C})$, yielded the best fit between diameter at breast height (D) and mass of given tree component, as compared to linear, exponential, and hyperbolic functions. Total aboveground biomass ranged from 30 Mg/ha for 8-year-old stands to 125 Mg/ha for a 63-year-old stand. Bolewood comprised 68% of the total aboveground biomass, followed by bole bark (12-16%), live branches (12-14%), foliage (2-6%), dead branches (2.3%), and current twigs (<1-2%). Whereas the relative proportions of bole bark and live branches increased slightly with age, the relative proportion of foliage declined slightly with age. The proportion of biomass in dominant and codominant trees increased from 66% at age 8 to 88% at age 63 yr. Aboveground NPP increased from 6.4 Mg/ha/yr at age 8 to a maximum of 11.6 Mg/ha/yr at age 32, remaining constant with further age. Leaf area index (LAI) increased from 2.6 m²/m at age

8 to 4.1 m²/m at age 63. There was a highly significant ($r = 0.945$) correlation between leaf production and bolewood production. Fine root (<3.0 mm) biomass ranged from 1.4-2.4 Mg/ha for stands 8 to 63 yr in age. Preliminary analyses revealed that 80% of the fine roots in the upper 10 cm of soil in the various stands were attributed to understory vegetation.

Publications: 84/01 to 84/12

RUARK, G.A. 1985. A refined soil coring system. Soil Sci. Soc. Am. J. 49:(in press).

01.096 CRIS0087161
**REGIONAL INTEGRATED LAKE-WATERSHED
 ACIDIFICATION STUDY (RILWAS)**

BOCKHEIM J G; Soil Science; University of Wisconsin, Madison, **WISCONSIN** 53706.
 Proj. No.: WIS02710 Project Type: STATE
 Agency ID: SAES Period: 01 JUL 85 to 30 JUN 88

Objectives: To monitor the quantity and quality of wet and dry deposition, throughfall, and soil water leachate in various forest types at Round and Eastmile Lakes, northwest Wisconsin, as part of an interdisciplinary study dealing with the effects of acidic deposition on lake chemistry. To study specific mechanisms whereby the terrestrial ecosystem buffers acidic deposition, including foliar leaching, ion exchange, and mineral weathering. To apply the ILWAS Model to predict the effects of acidic deposition on lake chemistry.

Approach: Wet and dry deposition will be collected weekly at each watershed using Aerochem Metric 301 collectors. Nine throughfall collectors have been installed on 4 plots containing representative vegetation at each watershed. Twelve soil water collectors have been located at each of 2 depths (75 and 600 mm) on each plot. All solutions are being analyzed for pH, EC, Al, Si, Ca, Mg, K, Na, NH(4), SO(4), NO(3), Cl, and HCO(3). Temporal changes in tissue concentrations are being measured to determine the relative contributions of foliar leaching and atmospheric deposition to throughfall.

Progress: 84/01 to 84/12. This project is part of an international research program entitled "Regional Integrated Lake-Watershed Acidification Study," funded by the Electric Power Research Institute. The primary objective of the study is to examine the effects of acidic deposition on biogeochemistry of two watersheds featuring contrasting lakes in northwestern Wisconsin. The findings to date are as follows. Whereas the canopies of deciduous forest types such as birch, aspen, and oak reduce the fluxes of H⁺ ion, SO(4), and NO(3) in bulk precipitation, throughfall from the canopies of coniferous types such as jack and red pines are enriched in these constituents. Although deciduous forest types are able to neutralize acidic deposition, the ultimate source of buffering is in the soil, as determined by a similarity in ion fluxes at the base of the effective rooting zone (60 cm) on plots with and without forest cover. The

primary mechanism whereby the soils in northwestern Wisconsin buffer acidic deposition appears to be silicate hydrolysis rather than ion exchange. This is supported by simulated weathering studies conducted on soil columns in the laboratory. Whereas leaching with distilled water (pH 5.6) yielded low amounts of Si and negligible change in pH of the extract, leaching with dilute sulfuric acid (pH 3.0) resulted in large concentrations of Si (2 mg/L) and nearly equivalent reduction in pH of the extract as compared to the leaching solution.

Publications: 84/01 to 84/12

- BOCKHEIM, J.G. 1984. Acidic deposition effects on forest soils and site quality, pp. 19-35. In: Forest responses to acidic deposition. Proc. of the conf., held on Aug. 3-4, 1983, Univ. of Maine, Orono.
- ESSER, J.M. 1984. Biogeochemistry of Quercus and Pinus ecosystems in northwestern Wisconsin. M.S. thesis, Dept. of Soil Science/Forestry, Univ. of Wisconsin-Madison. 103 pp.
- JEPSEN, E.A. and BOCKHEIM, J.G. 1984. Acidic deposition influences on biogeochemistry of four forest ecosystems in northwestern Wisconsin. In: Proc. Sixth Internat. Conf. Environmental Biogeochemistry, Oct. 10-14, 1983.
- BOCKHEIM, J.G., LEIDE, J.E. and ESSER, J.M. 1984. Acidic deposition and ion movements in forest soils of northwestern Wisconsin. In: Proc. Sixth North Amer. Forest Soils Conf., June 20-23, 1983, Knoxville, TN, in press.

01.097 CRISO089148
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

BOCKHEIM J G; Soil Science; University of Wisconsin, Madison, **WISCONSIN** 53706.
 Proj. No.: WISO2759 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographic and temporal trends in the chemical climate of North America; and assess the effects of atmospheric deposition on the following.

Approach: Cooperate with the Wisconsin Department of Natural Resources (WDNR) in collecting, characterizing, and processing precipitation data at Rhinelander, WI and Spooner, WI; cooperate with WDNR and the U.S. Geological Survey in an effects research program, including effects on forests, soils, water quality, and aquatic ecosystem through biogeochemical studies.

Progress: 84/01 to 84/12. The National Atmospheric Deposition Program (NADP) (IR-7) is responsible for collecting and analyzing wet and dry deposition at 150 sites across the U.S. Wetfall collections are made on a weekly basis and dry fall on a biweekly basis. Field measurements include pH, electroconductivity, and volume. Laboratory measurements include pH, conductivity, Ca, Mg., K, Na, NH(4), NO(3), C1,

SO(4), and PO(4). Three stations are located in Wisconsin, including Trout Lake in Vilas County, Spooner in Washburn County, and Lake Dubay in Portage County. The Aerochem Metric wet/dry collector at Trout Lake was purchased by the University of Wisconsin Agricultural Experiment Station. Mr. R. Becker of the Wisconsin Department of Natural Resources is responsible for the collections. The following summary is for the 1982 calendar year. Forty-four collections were made over the 12-month period. Total precipitation for the period was 959 mm, which is about 18% above the 30-year average. Wetfall pH ranged from 4.07 to 6.82 and averaged (unweighted mean) 5.0. The dominant cation in wetfall was H ion, followed by NH(4), Ca, Mg, Na, and K. Sulfate was the dominant anion, followed by NO(3), C1, and PO(4). The cation /anion balance was 1.0. The largest concentration of Ca, NO(3), and SO(4) occurred during the period 5/25 to 6/1/82.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

01.098 CRISO091538
GAINS, LOSSES AND MANAGEMENT OF SOIL NITROGEN

KEENEY D R; Soil Science; University of Wisconsin, Madison, **WISCONSIN** 53706.
 Proj. No.: WISO2822 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To assess the magnitude of and determine factors affecting losses and gains of soil nitrogen.

Approach: Factors affecting denitrification (specifically, the evolution of N₂O and N₂) will be evaluated and methods to minimize denitrification by controlling nitrification will be established. Evaluations will be made of the significance of the recently observed N₂O formation maxima during soil thawing. Studies in the laboratory will concentrate on interactions of environmental factors and soil properties. For this purpose, soils from other NE-146 investigators will be included. Research also will be conducted to evaluate the efficiency and mode of action of various compounds believed to inhibit nitrification.

Progress: 84/01 to 84/12. The effect of carbon dioxide in soil atmospheres, ranging from ambient to 100%, on N transformation was investigated. As carbon dioxide increased to 75%, nitrification rate decreased but nitrous oxide production from nitrification increased. At 100% carbon dioxide, nitrification and nitrous oxide production ceased. The effectiveness of the acetylene block on nitrous oxide reduction declined as carbon dioxide increased. High localized zones of carbon dioxide may affect nitrous oxide production. Acetylene was degraded under anerobic and aerobic conditions in an organic soil but only under aerobic conditions with a mineral soil. Acetone did not increased the rate of nitrate loss, but acetylene appeared to enhance denitrification. This points out some of the problems with the acetylene block technique. We also confirmed the strong inhibition of

nitrification by acetylene. Nitrification rate is very low in some forest soils. It was found that this was not due to lack of available phosphorus in a series of forest floor soils from climax ecosystems in central Wisconsin. Nitrous oxide fluxes at the soil surface and profile nitrous oxide concentrations in prairie, forest and manure-treated plots showed that nitrification at the soil surface and denitrification deep in the profile following heavy rains, are both sites of nitrous oxide production.

Publications: 84/01 to 84/12

- GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide production in aerobic soils under varying pH, temperature, and water content. *Soil Biol. Biochem.* 16:39-43.
- GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide emission from forest, marsh and prairie ecosystems. *J. Environ. Qual.* 13:448-452.
- GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide emissions from soils during thawing. *Can. J. Soil Sci.* 64:187-194.
- GOODROAD, L.L., KEENEY, D.R. and PETERSON, L.A. 1984. Nitrous oxide emissions from agricultural soils in Wisconsin. *J. Environ. Qual.* 13:557-561.
- KENEY, D.R. and GOODROAD, L.L. 1984. Nitrous oxide emissions from selected north-central U.S. ecosystems. p. 74-81. In V.P. Aneja (ed.) *Trans. Environmental Impact of Natural Emissions. Air Pollut. Control Assoc.*

CM 02 WATER

02.001 CRIS0090116
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS**

BOYD C E; Agricultural Exper. Station; Auburn
University, Auburn, ALABAMA 36830.
Proj. No.: ALA00587 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Small amounts of several types of surface soils will be confined in various kinds of containers in the laboratory. Rain water, representing different degrees of acidification, will be passed over, passed through, or agitated with the soils for different lengths of time. The changes of pH and alkalinity of the water will be measured. Ponds will be treated with hydrated lime and the residual effect of the lime in neutralizing acidity will be ascertained. The benefit of liming to fish and other aquatic life will be considered.

Progress: 84/01 to 84/12. Ponds were treated with sulfuric acid to produce different levels of alkalinity (three replications for each alkalinity value) and fish production was determined. All ponds were fertilized at same rate, but primary productivity decreased with decreasing alkalinity. The best fish production was achieved at 20 mg/l of alkalinity ($P < 0.05$). Production of sunfish did not differ significantly at alkalinity treatments of 1, 3, 5, and 8 mg/l.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

02.002* CRIS0089820
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS AND
MATERIALS**

BOHN H L; Soil Water & Engineering; University
of Arizona, Tucson, ARIZONA 85721.
Proj. No.: ARZT-172950-R-21-36

Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on c) the chemical composition of surface and ground waters.

Approach: The rainfall composition data accumulated by the USDA personnel at their Tombstone site since 1968 will be normalized with later data gathered under the auspices of Nc141. This data will be compared with the sulfur emissions from the nearby and other

copper smelters in Arizona. The rainfall data will also be related to the composition of the runoff water into the San Pedro River from the Tombstone Watershed.

Progress: 84/01 to 84/12. The western U.S. has been subjected to sulfur emissions from the smelting of lead, zinc, copper and other ores for almost a century. The smelting has decreased in the last decade due to low metal prices and the mines playing out. The SO_2 concentrations from smelting are high and usually the chimneys are low. The local effects on vegetation, however, appear to be minimal in the arid regions of the West. In more humid regions the total effect of the mining, including tree harvest for fuel, housing, mine timbers, as well as atmospheric emissions, has been much more drastic. The effects are reversible as indicated by the return of vegetation after smelting ceased. The decreased sulfur emissions from ore smelting is being offset by recent increases in coal combustion for electric power. The lower SO_2 concentration and higher fly ash content and taller smokestacks indicate that any sulfur effects will be slight and difficult to measure.

Publications: 84/01 to 84/12
BOHN, H.L. 1984. Potential affects of acid deposition in the West. Air Pollut. Contr. Assn., San Francisco, June 25.

02.003* CRIS0096913
**EFFECTS OF ATMOSPHERIC DEPOSITION ON FOREST
RESOURCES IN ARKANSAS**

BEASLEY R S; Forest Resources; University of
Arkansas, Monticello, ARKANSAS 71655.
Proj. No.: ARK01228

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 NOV 85 to 30 SEP 90

Objectives: To evaluate research programs designed to verify cause-effect relationships between forest decline and atmospheric deposition in Europe and the eastern U.S.; to characterize the current composition of precipitation, streamflow and soils in forest ecosystems in Arkansas and to determine the extent to which hydrologic processes; flow pathways and ecosystem characteristics modify or buffer acidic deposition; and measure long-term changes in atmospheric deposition and determine the effects of such changes on stream chemistry, aquatic organisms, soil properties and forest productivity.

Approach: Experimental forested watersheds in the Gulf Coastal Plain, the Athens Plateau and the Ouachita Mountains have provided detailed information on the hydrology and water chemistry of forest ecosystems in each physiographic province. These data will provide background information for expanding the work to evaluate effects of atmospheric deposition on forest soils, stream chemistry and forest productivity. Since measuring, sampling and collection devices are in place our initial work will involve additional soil and water chemical analyses such as sulfate, aluminum, pH

and conductivity. The evaluation of flow pathways will require collection trenches to intercept and sample subsurface and overland flow. Initial work will be concentrated in the Ouachita Mountains where soils and streams are highly sensitive to acidification due to inherently low alkalinity.

NO PUBLICATIONS REPORTED THIS PERIOD.

02.004* CRIS0089881
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS AND
MATERIALS

BURGY R H; CARROLL J J; FLOCCHINI R G; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
 Proj. No.: CA-D*-LAW-4311-RRProject Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America.

Approach: Studies will be conducted to identify and improve efficiency for collection of naturally- and anthropically-generated gaseous and particulate components added to, distributed by and deposited from the atmosphere which may have beneficial or injurious impact on components of terrestrial and aquatic ecosystems. Major sources and composition of atmospheric pollutants and atmospheric processes involved in their distribution and deposition will be investigated.

Progress: 84/01 to 84/12. During 1984, the Davis site operated on a continuous basis to monitor precipitation deposition. This portion of the project is attempting to identify acidic deposition products contained in rain samples and to define the sources of acidic constituents that contribute to acidity of rainfall here. The program was modified on July 1, 1984 to discontinue collections of dry deposition samples (only a few stations in the U.S. will take dry samples hereafter). The Davis site was inspected by NADP this year and minor adjustments in equipment were made to conform to network specifications. A total of 20 rain samples were collected in the year, these yielding pH values ranging from 5.0 to 6.5. The average of all samples is about 5.8 pH units, indicating a nearly neutral acidity in Davis rainfall. Spring rains tend to have higher pH values (about 6.0) and Fall rains tend to be lower (5.0 to 5.5), suggesting some effect due to strong inflow in early winter storms that generally translate into the upper delta area (Davis) from the southwest and include trajectories passing over the metropolitan bay-delta region. The limited numbers of events sampled makes all interpretations inconclusive, and will require longer experience to resolve.

Publications: 84/01 to 84/12

02.005* CRIS0089880
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS

WHITTIG L D; BURAU R G; HUNTINGTON G L; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
 Proj. No.: CA-D*-LAW-4312-RRProject Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Studies will evaluate sensitivity of soils, waters, and terrestrial and aquatic organisms to atmospheric deposition, chemical and biological processes in soils, waters and organisms affected by atmospheric deposition, and terrestrial processes and agricultural and forest practices as may influence effects of deposition on aquatic systems.

Progress: 84/01 to 84/12. Investigations under this project contribute to an integrated long-term study of potential impacts of atmospheric deposition on terrestrial and aquatic ecosystems of the Sierra Nevada. Centered in Sequoia National park, this project focuses on buffering characteristics of soils of the program study area, on release of chemical elements from the soils in response to acidity and alkalinity inputs, on mechanisms involved in dissolution and transport of mineral elements and on the input-output balance for sulfuric acid added to the soil systems. A total of 26 surface profile samples from representative soils have been subjected to a buffer performance test involving graded additions of H_2SO_4 and $Ca(OH)_2$. The pH of the systems was measured weekly for 6 weeks to observe the time course of buffering for each profile sample. Aqueous extracts from treated samples have been analyzed for major cations and anions. The pH data have been transformed into van Slyke buffering index curves and apparent sulfate adsorption has been calculated. The mineralogy has been qualitatively determined for silt and clay fractions of 12 of the surface profile samples. Buffering and sulfate adsorption have been unexpectedly strong in many samples while element release has been unexpectedly small. In addition to a wide diversity of phyllosilicate minerals in different soils of the area, there is a relatively high proportion of glass in a number of surface samples, suggesting a volcanic ash deposition source.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

02.006* CRIS0011628
TRACE ELEMENT STUDY OF THE SOIL-PLANT-WATER SYSTEM

BRADFORD G R; PAGE A L; LUND L J; Soil & Environmental Sci; University of California, Riverside, **CALIFORNIA** 92521.
Proj. No.: CA-R*-SES-1026-H Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 89

Objectives: The primary objectives are to detect potential trends toward acidification of Sierra Nevada lakes and patterns of chemical contamination of soils surrounding a generating station in the Mohave Desert.

Approach: One hundred and twenty-four Sierra Nevada lakes will be sampled by helicopter during the spring thaw and analyzed for pH, EC, and major cations and anions to monitor chemical changes which will reflect potential trends toward acidification. Surface and subsurface soils will be collected at different distances and directions annually, or as the data suggests, in the vicinity of a coal-fired generating station in the Mohave Desert and the aqueous extracts analyzed by a plasma direct reading spectrograph to monitor chemical contamination of the soil.

Progress: 84/01 to 84/12. Slight year to year variations pH and EC values in Sierra Nevada lake waters sampled annually the past 5 years appear to be the result of variations in seasonal snowfall. Both the pH and EC values decrease seasons of high snowfall probably because lake water is more like snow water during periods of heavy runoff. The mean total alkalinity (ANC) of lake waters was 34.7 μ eq/L for 1984 compared to 35.4 μ eq/L for 1983, indicating the extreme sensitivity of the waters to acid input but showing no significant change during the past year. Elevated salt content, particularly Na, B, Mo and SO₄, was identified in saturation extracts of soil collected within 1.8km radius of a coal-fired electric generating station in the Mohave Desert in 1983 following 13 years operation.

Publications: 84/01 to 84/12
ELAMAMY, M.E., FOX, C.A., BRADFORD, G.R., PAGE, A.L., and NODVIN, S.C. 1984. The alkalinity of Pristine lakes in the High Sierra Mountains. Proceedings of Air pollution Control Association Meetings, San Francisco, California. June

02.007* CRIS0064880
CHEMICAL REACTIONS IN SOILS AND THEIR EFFECT ON PLANT GROWTH

LINDSAY W L; BOYLE F W JR; WALTHALL P M; Agronomy; Colorado State University, Fort Collins, **COLORADO** 80523.
Proj. No.: COLO0126 Project Type: HATCH
Agency ID: CSRS Period: 07 OCT 83 to 30 JAN 88

Objectives: Seed a basic understanding of the inorganic chemical reactions that occur in soils. Apply chemical principles to product and interpret elemental solubility relationships in soils. Relate solubility relationships of chemical elements to plant growth, nutrient deficiencies, elemental toxicities, nutrient imbalances, selection and use of fertilizers, and the formation and weathering of soils.

Approach: Chemical data from the literature will be computerized and used to predict chemical reaction and solubility relationships in soils. These models will be tested experimentally. Missing critical data will be identified. Carefully planned experiments will be established to obtain the missing information. The findings will be used to correct existing problems and to plan future experiments.

Progress: 83/10 to 84/09. Acid rain research in Rocky Mountain National Park shows the formation of smectite minerals which depress A1 activity and allows the pH to drop into the range of 3.3 to 4.5. This is much lower than found in the Eastern U.S. where acidity problems are considered to be severe. Processed oil shales have undesirable pH values near 12. The high pH is the result of destructive loss of carbonates and formation of silicate minerals such as CaSiO₃ (wollastonite), CaMg(SiO₃)(2) (diopside), and MgSiO₃ (clinoenstatite). Recarbonation of such shales lowers the pH to 8.0 with the reformation of carbonate minerals. The effect of high pH and recarbonation on mineral transformations and solubilization of various metals ions is being studied. The cause of zinc deficiency in paddy rice is under investigation. Reducing conditions resulting from flooding greatly increased the solubilities of Fe and Mn which have a depressing effect on the uptake of zinc. Reduction caused the precipitation of FeCO₃ (siderite) and Fe₃(OH)(8) (ferrosic hydroxide), which raised the activity of Fe. We hypothesized that the increased activity of Fe depresses Zn activity through the formation of ZnFe₂O₄ (franklinite). This hypothesis will be examined further in subsequent studies. Activity measurements of Ca were made in both acid and calcareous soils. In calcareous soils Ca activities can be related to calcite equilibria.

Publications: 83/10 to 84/09
LINDSAY, W.L. 1984. Soil and plant relationships associated with iron deficiency with emphasis on nutrient interactions. J. Plant Nut. 7:489-500.
STUMPE, J.M., VLEK, P.L.G. and LINDSAY, W.L. 1984. Ammonia volatilization from urea phosphates in calcareous soils. Soil Sci. Soc. Am. J. 48:921-927.
ELRASHIDI, M.A. and LINDSAY, W.L. 1984. Fluorine supplement to Technical Bulletin 134: Selection of standard free energies of formation for use in soil chemistry. Colo. Agric. Exp. Sta., Fort Collins, Colorado.

02.008* CRIS0096764
THE EFFECT OF ATMOSPHERIC DEPOSITION ON SOILS,
PLANTS, AND WATERS

REUSS J O; WALTHALL P M; LINDSAY W L;
 Agronomy; Colorado State University, Fort
 Collins, **COLORADO** 80523.
 Proj. No.: COL00623 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 85 to 30 JUN 90

Objectives: To clarify the chemical processes that occur when soils are impacted by acid deposition, and the effects of these processes on the chemical composition of soil solutions and drainage waters. To evaluate the probability of deleterious effects occurring from current levels of deposition due to anthropogenic sources, the nature of such effects, their severity, and the time scale on which such effects are likely to be observed. To determine the probable effects of changes in current deposition levels, particularly acid deposition, on our soil, plant and water resources.

Approach: The general approach will involve a combination of theoretical studies using chemical models, and field and laboratory studies to evaluate the applicability of these models. Specific approach will include, but not be limited to, the following: 1. Development and testing of simple and accurate laboratory methods to determine input parameters required by current chemical models. 2. Field and laboratory testing of theoretical relationships utilized in chemical models. 3. Evaluation of cation replacement capacity of soil minerals. 4. Further model development, including refinement and expansion of current models and investigation of entirely different modelling approaches.

02.009* CRIS0083194
ECONOMIC ANALYSIS OF NATURAL RESOURCE AND
ENVIRONMENTAL ISSUES IN COLORADO

YOUNG R A; WALSH R G; HUSZAR P C; Economics;
 Colorado State University, Fort Collins,
COLORADO 80523.
 Proj. No.: COL00328 Project Type: HATCH
 Agency ID: CSRS Period: 08 AUG 80 to 30 SEP 83

Objectives: Objectives---The overall objective of the research is to study the demand, supply and economic value of Colorado Natural resources and environmental commodities, and to evaluate market and non-market allocative mechanisms for achieving maximum social return from the resources.

Approach: Analyze the value of water in withdrawal uses (agriculture, households, industries and non-withdrawal uses (recreation); Investigate the economic forces underlying conservation of rural lands to urban uses and evaluate alternative public policies for influencing land use and the extent of urban sprawl evaluate the demand for the management of outdoor recreation on public lands and waters. Evaluate the impact of

growing demand for energy on Colorado's economy and environment. Study the economic impacts of natural hazards. Evaluated the economic benefits of air and water quality improvement. Formulate and test new methodologies for ascertaining the economic impacts (in allocative, distributive, and regional dimensions) of changes in the demand for non-marketed environmental goods and services.

Progress: 83/01 to 83/09. The overall objective of this research program is to study the demand, supply and economic aspects of Colorado's natural resources and environmental endowments, to evaluate market and non-market allocation mechanisms for achieving optimal social returns from natural resources, and to assist in conflict resolution via public policy analysis arising from competing uses of these resources. During this time period, research continued on water use allocations and quality aspects, groundwater use in agriculture, an updating of Colorado water case law, option demand for recreational uses, values of hunting and fishing in Colorado, some preliminary work on the grasslands plowout problem in eastern Colorado, and related natural resource economics issues. Due to reorganization of agricultural programs at CSU, a new Department of Agricultural and Natural Resource Economics was established in the College of Agricultural Sciences on July 1, 1983. As a result of this action, this project (Colo 328) is being terminated and will be replaced by a new reoriented research project, "Natural Resource Economics and Regional Resource Allocation Issues", effective October 1, 1983.

Publications: 83/01 to 83/09

- DAVITT, G.J. and WALSH, R.G. 1983. A demand function for length of stay on ski trips to Aspen. Journal of Travel Research. 21(Spring).
- MCKEAN, J.R. and WEBER, J.C. 1983. The economy of Lincoln, Sublette, Sweetwater and Uinta Counties, Wyoming, Rock Springs BLM District, Technical Report No. 40, Colorado Water Resources Research Institute, Colorado State University.
- MCKEAN, J.R. and NOBE, K.C. 1983. 1981 Colorado sportsman survey: Direct and indirect effects of expenditures for hunting and fishing in Colorado (Contract Report for Colorado Division of Wildlife and Bureau of Land Management).
- GILLIAM, L.O., MILLER, N.P. and WALSH, R.G. 1983. Congestion and willingness to pay for expansion of skiing capacity. Land Economics 59. (May 1983).
- GILLIAM, R.A., LOOMIS, J.B. and WALSH, R.G. 1984. Valuing option, existence, and bequest demands for wilderness. Land Economics 60. (February 1984).

02.010* CRIS0077142
ATMOSPHERIC DEPOSITION AND EFFECTS ON
AGRICULTURAL AND FORESTED LAND AND SURFACE
WATERS

GIBSON J H; Natural & Environmental Res;
 Colorado State University, Fort Collins,
COLORADO 80523.

Proj. No.: CDLO2014 Project Type: SPECIAL GRANT
Agency ID: CSRS Period: 03 JUL 78 to 30 SEP 80

Objectives: Establish Atmospheric Deposition Network to determine spatial & temporal trends in supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter. Determine relative importance of precipitation & dry particulate matter. Develop optimum procedures. Determine stability of collection of precipitation constituents. Investigate transport & transformations. Organize & coordinate research in SAES, FS, & other institutions on the effects of atmospheric deposition on the productivity of agricultural crops, forests, range, wet lands, & surface waters.

Approach: Provide coordination for development of a program nationally to meet objectives including organization of central analytical laboratory & data analysis management service.

Progress: 82/01 to 82/12. Funds made available by the North Central Region of the State Agricultural Experiment Station (NC-141) and the U.S. Department of Agricultural CSRS are combined to support the coordination, data management and publications for the NC-141-sponsored program in atmospheric deposition referred to as the National Atmospheric Deposition Program (NADP). This support has been primarily directed to the establishment and coordination of a national atmospheric deposition monitoring network. Additional support has been obtained from other Federal agencies including BLM, EPA, USGS, USFS and NOAA, and a number of sites are supported by state agencies and private corporations. Since the beginning of the program in 1978, this monitoring network has expanded to 108 operating sites across the country, including Alaska and American Samoa. In 1983, NADP will become the core of the National Trends Network (NTN) which is being established under the mandated National Acid Precipitation Assessment Plan, with the addition of approximately 40 monitoring sites anticipated by 1984. Data published by the program now includes eight volumes covering data from July of 1978 through December of 1980. In addition, the monitoring data is available on computer tape either from the Natural Resource Ecology Laboratory, Colorado State University, or from the Environmental Protection Agency Data Management System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12
NATIONAL ATMOSPHERIC DEPOSITION PROGRAM. 1982. NADP Instruction Manual: Site Operation. Beigelow, D.S. (Editor). Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO. 30 pp.

02.011* CRIS0089822
CHEMISTRY OF ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

GIBSON J H; Natural Resource Ecology Lab; Colorado State University, Fort Collins, COLORADO 80523.
Proj. No.: CDLO0223 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife, and fish; c) the chemical composition of surface and ground waters; and d) atmospheric visibility and the corrosion of metals, masonry.

Approach: Provide coordination to further develop and maintain the National Atmospheric Deposition Program (NADP) chemical deposition network as well as the NAPAP National Trends Network (NTN).

Progress: 83/01 to 83/12. This project furnished administrative support for research carried on under the IR-7 interregional research project goals stated above.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

02.012* CRIS0081176
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

GIBSON J H; Office of The Director; Colorado State University, Fort Collins, COLORADO 80523.
Proj. No.: CDLO0223 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish Atmospheric Deposition Network to determine spatial and temporal trends in supply of beneficial nutrient elements and potentially injurious substances in precipitation & dry particulate matter. Determine relative importance of precipitation & dry particulate matter. Develop optimum procedures. Determine stability of collection or precipitation constituents. Investigate transport & transformations. Organize and coordinate research in SAES, FS & other institutions on the effects of atmospheric deposition on the productivity of agricultural crops, forests, range, wet lands & surface waters.

Approach: A program coordinator's office will be maintained to provide support for the NC-141 regional research project including project coordination, travel, special analyses and other project activities as needed by the regional research project. (This is to cover the RRF Off-the-Top Trust Fund to NC-141).

Progress: 82/01 to 82/12. Funds made available by the North Central Region of the State Agricultural Experiment Station (NC-141) and the U.S. Department of Agricultural CSRS are combined to support the coordination, data management and publications for the NC-141-sponsored program in atmospheric deposition referred to as the National Atmospheric Deposition Program (NADP). This support has been primarily directed to the establishment and coordination of a national atmospheric deposition monitoring network. Additional support has been obtained from other Federal agencies including BLM, EPA, USGS, USFS and NOAA, and a number of sites are supported by state agencies and private corporations. Since the beginning of the program in 1978, this monitoring network has expanded to 108 operating sites across the country, including Alaska and American Samoa. In 1983, NADP will become the core of the National Trends Network (NTN) which is being established under the mandated National Acid Precipitation Assessment Plan, with the addition of approximately 40 monitoring sites anticipated by 1984. Data published by the program now includes eight volumes covering data from July of 1978 through December of 1980. In addition, the monitoring data is available on computer tape either from the National Resource Ecology Laboratory, Colorado State University, or from the Environmental Protection Agency Data Management System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12
NO PUBLICATIONS REPORTED THIS PERIOD.

02.013* CRIS0085035
DEVELOPING FORESTS: EFFECTS ON SOIL AND WATER QUALITY

KRUG E C; FRINK C R; Soil & Water; Connecticut Agric Expt Sta, New Haven, **CONNECTICUT** 06504.
Proj. No.: CONH00744 Project Type: HATCH
Agency ID: CSRS Period: 07 AUG 81 to 16 SEP 83

Objectives: Determine changes of five benchmark soils established in 1927 under developing Connecticut forests. Characterize soils from farm fields, developing and mature forests in the Bantam Lake watershed. Determine sediment characteristics and phosphorus in runoff from these soils. Determine ability of sediment to sorb or release phosphorus after deposition in Bantam Lake.

Approach: Determine physical, chemical and mineralogical properties of soils collected from long term forest plots and compare with analyses obtained 1927-1931. Analyze soils across the successional gradient in the Bantam Lake watershed. Measure phosphorus and suspended sediment in low order streams during low and high flow in the watershed. Incubate silt-sized samples from these watershed soils in sediments in Bantam Lake.

Progress: 83/01 to 83/09. Several small lakes in Connecticut have apparently become acidified according to a recent study of lakes in New England by the U.S. Fish and Wildlife Service. The most pronounced acidification was

observed in Emmons Pond in Hartland, CT where the pH is now approximately 4.6. Preliminary investigations revealed that the pond was created by damming a former swamp. Most of the watershed was farmed at one time but now supports a mature stand of hemlock. Streams entering the lake pass through and are acidified by sphagnum peat moss. The specific mechanisms responsible for acidification will be examined more thoroughly in the coming year under Hatch 747.

Publications: 83/01 to 83/09

KRUG, E.C. and FRINK, C.R. 1983. Acid rain on acid soil: A New Perspective. Science 221:520-525.

KRUG, E.C. and FRINK, C.R. 1983. Effects of acid rain on soil and water. Conn. Agr. Exp. Sta. Bull 811. In Press.

02.014* CRIS0083303
IDENTIFICATION AND MOVEMENT OF ORGANIC CHEMICALS IN SOILS

SAWHNEY B L; FRINK C R; KOZLOSKI R; Soil & Water; Connecticut Agric Expt Sta, New Haven, **CONNECTICUT** 06504.
Proj. No.: CONH00742 Project Type: HATCH
Agency ID: CSRS Period: 01 JAN 81 to 29 JUL 85

Objectives: Investigate the reactions and movement of organic chemicals in soils to provide safe disposal of organic pollutants. To improve the purge and trap method for the analysis of volatile organic compounds by GC and GC/MS.

Approach: Measure reaction and movement of organic chemicals in soil columns in the laboratory. Measure organic chemicals in leachates from landfills, industrial disposal sites, and agricultural fields. Develop predictive models for movement of chemicals. Study trap adsorbents, columns, and relative volatility. After volatility with acids, bases, redox and other reagents.

Progress: 85/01 to 85/07. Investigation of the movement of organic pollutants in the groundwater beneath a landfill in Granby, CT have been completed. Diethyl ether, methylethyl ketone, methylisobutyl ketone, benzene and toluene were the major pollutants identified. The plume was found to move from east to west as predicted from the general hydrology of the region. However, a number of borings revealed a north-south trough in the bedrock that bisects the landfill site. During low flow, leachate appeared to be caught in the trough and redirected into southerly flow. Capping the landfill site and diversion of storm water effected rapid decrease in the concentration of pollutants in monitoring wells at the site, but had little influence on bedrock wells to the south. Thus, local hydrologic features may be important in determining the exact pattern of movement of pollutants.

Publications: 85/01 to 85/07

SAWHNEY, B.L. 1985. Vapor-phase sorption and polymerization of phenols by smectite in air and nitrogen. Clay and Clay Min.

33(2):123-127.

SAWHNEY, B.L. and KOZLOSKI, R.P. 1985. Reply to "Comments on Organic Pollutants in Leachates from Landfill Sites." J. Environ. Qual. 14(1):157.

02.015* CRIS0089292
AN ASSESSMENT OF ACID RAIN ON LEACHING ELEMENTS
FROM DELAWARE SOILS INTO GROUND WATER

SPARKS D L; Plant Science; University of Delaware, Newark, **DELAWARE** 19711.
 Proj. No.: DELO0768(1) Project Type: STATE
 Agency ID: SAES Period: 01 OCT 81 to 30 SEP 82

Objectives: Characterize the cations which might be released into groundwater from soil systems under acid rain conditions; and determine the kinetics of ionic release, especially aluminum, into groundwater from soil systems under acid rain conditions.

Approach: Three major soil types from Delaware and three pure clay minerals common in Delaware soils will be used in the study. The soils will be fully characterized as to their chemical, mineralogical, and physical properties. The effect of acid rain deposition on the kinetics of release of anions and cations will be investigated using miscible displacement technique. Soil profiles will be assembled in 100 cm long C-column systems, attached to a fraction collector and leached with simulated acid rain water of pH 5.6, 4.8, 3.4, and 2.5 at a flow velocity of 1.0 and min. The clays will be leached using a Nucleopore filter. Twenty ml of leachate will be collected every 20 minutes for at least 72 hours. The leachates will be analyzed for the macro and micro elements and for heavy metals. The kinetic data will be fitted to numerous theoretical equations.

02.016* CRIS0048807
ECONOMIC IMPACTS OF ENERGY USE AND DEVELOPMENT
ON AGRICULTURE AND NATURAL RESOURCES

ANDERSON W D; GREEN J W; USDA Economic Research Service, Washington, **DISTRICT OF COLUMBIA** 20250.

Proj. No.: NRED-LUC&D-4727

Project Type: INHOUSE
 Agency ID: ERS Period: 01 JAN 76 to 30 DEC 83

Objectives: Estimate economic and locational impacts of coal mining, transportation, and utilization upon agriculture, land, water, air, and natural resource systems.

Approach: Project levels and locational impacts of coal development for the United States. Assess the impact of the 1990 base case projection on agriculture, and on land, water, and air resources. Provide special analyses to the Universities Research Group on Energy (URGE) (funded by EPA) to help assess alternative strategies for reducing damage from coal development, especially from coal-related

pollution.

Progress: 82/10 to 83/09. A draft report was prepared on the impacts of energy development on rural resources. The principal investigator was assigned to EPA for FY 83 to complete specific data and modeling assignments for that agency.

Publications: 82/10 to 83/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

02.017* CRIS0120146
INDUSTRIAL AND AGRICULTURAL POLLUTION IMPACTS

BARSE J; USDA Economic Research Service, Washington, **DISTRICT OF COLUMBIA** 20250.
 Proj. No.: NRED-EIRS-4798 Project Type: INHOUSE
 Agency ID: ERS Period: 01 OCT 83 to 30 SEP 86

Objectives: Calculate economic benefits to farmers, by region, and to consumers of alternative strategies to mitigate crop damage caused by gaseous air pollutants, principally ozone and sulfur dioxide.

Approach: Evaluate the degree of physical and economic damage to agricultural land and water, including groundwater, from toxic residuals, such as industrial chemical waste dumps.

Progress: 83/10 to 84/09. Literature in the physical and biological sciences and in economics on the impacts of air pollutants and acid rain on agriculture have been reviewed. An annotated bibliography, reflecting this review has been prepared and peer reviewed, and is to be published in FY 1985. Analytical work to project the economic impacts of ozone pollution on agricultural producers and consumers of farm products has started. The extent of groundwater pollution from toxic residuals, including those from pesticides and fertilizers as well as hazardous chemical wastes, is being evaluated. Planning is starting to analyze economic impacts upon rural areas once the extent of such pollution of groundwater is understood.

Publications: 83/10 to 84/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

02.018* CRIS0089958
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON
AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS

RIEKERK H; GHOLZ H L; CANFIELD D E; Forest Resources & Conservatn; University of Florida, Gainesville, **FLORIDA** 32611.
 Proj. No.: FLA-FOR-02321 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America, (Network Research), and to assess the effects of atmospheric deposition on land productivity, animal productivity, and water quality (Effects Research).

Approach: Network Research. Wet/dry fall collection stations in Florida in association with weather stations of ongoing research programs directly benefitting from the atmospheric deposition data. Weekly collection and sample shipment with weather data to, and return of data and synthesis reports from NADP central laboratory. Effects Research. Comparative importance of wet/dry fall on nutrient status of plants, soil and waters (Proj. Stat., A4). Effects wet/dry fall on forest nutrient cycling and forest tree growth (B1, 2). Influence on Al mobility and toxicity to fine tree roots (B6).

Progress: 83/10 to 84/09. Atmospheric deposition was monitored weekly at the Bradford Forest weather station in north-central Florida from Jan 1978 through Aug 1984. Acidity data from the first five years showed a highly significant drop of 0.2 pH units per year down to pH 4.6. Data from the sixth year initially followed the same trend but a reversal began after the summer of 1983 raising the average pH to about 5.0 during the summer of 1984. Plant nutrient inputs with rainfall during 1983 remained similar to that of the previous year and appeared to be significant for the longterm productivity of the sandy acid-leached pine flatwoods soils.

Publications: 83/10 to 84/09

RIEKERK, H. and KORHNAK, L.V. 1984. Environmental Effects of Silviculture in Pine Flatwoods. In 'Third Biennial Silvicultural Research Conference' Atlanta, GA, November 1984: (In press).

02.019* CRIS0086507
APPLICATION OF WATER QUALITY MODELS FOR AGRICULTURAL AND FORESTED WATERSHEDS

MANSELL R S; RAD P S C; Soil Science; University of Florida, Gainesville, FLORIDA 32611.
Proj. No.: FLA-SDS-02112 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Modify, develop, and/or adapt process models of water, sediment and chemical transport for surface and subsurface flow.

Approach: Mechanistic transport models will be developed to describe subsurface movement of water and solutes through sandy soil occurring on small land areas having relatively homogeneous vegetative cover, topography and profile characteristics. One-dimensional numerical models will be used where the depth to the groundwater table is great and two-dimensional numerical models will be used for tuber- or ditch-drained soils with a water table located at shallow depth. Adsorption-desorption, microbiological transformation, and plant uptake sink terms will be included in certain of the models. The models will be verified and validated using water quality data for soil solution, groundwater, and drainage water from small experimental land areas.

Progress: 83/10 to 84/09. A chromatographic model as developed for the purpose of simulating multi-species leaching of cations in aggregated soil during infiltration with "acid rain". Instantaneous ion exchange was assumed to occur between ions in sorbed and solution phases. The soil solution was divided into mobile and immobile (stagnant) regions, with ion occurring in both regions. Ions in the mobile solution were assumed to undergo exchange with readily-accessible sites in the soil matrix, whereas ions in the immobile solution undergo exchange with slowly-accessible sites. A rate transfer of individual cations between the mobile and immobile regions provides a kinetic characteristic for ion absorption by exchange sites located in regions of immobile solution. The model was solved for binary and tertiary exchange systems with mono and hetero-valent ions. Steady soil water flow conditions were assumed. A sensitivity analysis of model parameters was performed.

Publications: 83/10 to 84/09

NO PUBLICATIONS REPORTED THIS PERIOD.

02.020* CRIS0089826
CHEMISTRY OF ATMOSPHERIC DEPOSITION -- EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

RHUE R D; MANSELL R S; Soil Science; University of Florida, Gainesville, FLORIDA 32611.

Proj. No.: FLA-SDS-02321 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Objectives: To assess the effects of atmospheric deposition on the productivity of crops, forest trees, and soils.

Approach: In a field and laboratory study, simulated acid rain at various pH's will be applied to soils. An established field plot site on a Typic Quartzipsamment soil near Lake McCloud in North Central Florida will continue to be irrigated with acid rain (70:30 mixture of H₂SO₄:HNO₃) adjusted to pH 3.0, 3.7, and 4.7 (control). Porous glass suction tube lysimeters installed at 15-75 cm soil depths will be used to collect soil solutions for analyses of various elements and pH. Pine seedlings will be planted in selected plots and irrigated with control and acid rain. An Al treatment will be superimposed on several acid rain plots.

Progress: 83/10 to 84/09. A multicomponent chromatography model has been used to describe cation leaching in soil columns treated with acid solution. In the model, soil water was divided into mobile and immobile region, with ion exchange assumed to occur instantaneously in the region contacting the mobile water. A rate-limited transfer of cations between mobile and immobile regions was included in the model and resulted in delayed ion exchange reactions at surfaces contacting the immobile water. The model has been solved for binary and tertiary exchange systems with mono- and heterovalent ions. The model predicts breakthrough curves

which are in qualitative agreement with results from cation leaching studies using soil columns. The extent to which experimental breakthrough curves can be simulated by the model depends on the use of appropriate measured values for cation selectivity coefficients for a given soil. Effects are currently underway to evaluate the validity of certain assumptions used in developing the model. These include the assumptions of constant cation exchange capacity, that H ions are removed from solution only by ion exchange reactions, and that local equilibrium exists with respect to all ion exchange reactions.

Publications: 83/10 to 84/09

NO PUBLICATIONS REPORTED THIS PERIOD.

02.021* CRIS0083289
EFFECTS OF ACID PRECIPITATION ON SELECTED SOILS OF THE SOUTHEASTERN UNITED STATES

VOLK B G; GRAETZ D A; BITTON G; Soil Science; University of Florida, Gainesville, **FLORIDA** 32611.

Proj. No.: FLA-SOS-02058 Project Type: STATE
 Agency ID: SAES Period: 01 SEP 80 to 31 DEC 82

Objectives: To examine the affects of acid precipitation on the chemical properties of soils, including changes in soil nutrient supply and release of potentially toxic substances. To determine the relationship between organic matter decomposition and acidification. To determine the effects of acid rainfall on nitrogen transformations in soils, including N(2) fixation, mineralization, nitrification and denitrification and to assess the impact of acidification on soil microbial populations.

Approach: Acid rain, pH 3.7, will be applied on transects of a sandhill watershed site with typic quartzipsamments soils. Change in soil microbiology, chemistry, and concentrations of elements in percolation water will be monitored. Latobratoy soil columns using soils from various locations will be monitored for changes caused by acid rain leaching.

Progress: 83/01 to 83/12. Investigations using artificially acidified irrigation water (70:30, H(2)SO(4):HNO(3)) at pH 3.0, 3.7 and 4.7 over a two year period at a lake site in north central Florida suggest a relatively high and rapid loss of nutrients from the soil surface to the water table 4 m below. Considering the low CEC (3.5 me/100 g), the low base saturation (4%) and the high hydraulic conductivity (74 cm/hr) at this site, the implication with respect to the rooting zone of natural vegetation is clear. The magnitude of leaching also depends on the nature of the ion, the depth being considered and the degree of acid treatment. Readsorption of ions in the soil profile was shown to occur, which further complicates overall assessment of the real effect of acid rain. Most of the applied water, regardless of amount, is lost from the soil site to the water table within 48 hours. Lateral movement of the groundwater to the lake likewise was very fast, due to the high

hydraulic conductivity. There was essentially little non-veritcal flow to the water table, and horizontal wave movement towards the lake was rapid, despite the essentially flat water table extending more than 50 meters from the lake. The effect of the acid treatments from a very large rain event could be observed in the groundwater near the lake within 24 hours.

Publications: 83/01 to 83/12

VOLK, B.G., BYERS, G.E., BITTON, G. 1983.

Effects of acid precipitation on a typic quartzipsamment soil in Florida, USEPA National Acid Precipitation Assessment Program Effects Research Review Summaries. Feb. 21-25, 1983.

VOLK, B.G., and BYERS, G.E. 1983. Effects of acid precipitation on a typic quartzipsamment soil in Florida. In Acid Deposition: Causes and Effects, Eds. A.E.S. Green and W.H. Smith, Government Industries, Sept. 1983. p. 265-282.

BITTON, G., VOLK, B.G., BYERS, G.E. 1983. Effects of acid precipitation on microbiological and chemical parameters in soil. Developments in Acid Zone Ecology and Environmental quality. VIII.

02.022* CRIS0075198
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

GILMORE A R; Forestry; University of Illinois, Urbana, **ILLINOIS** 61801.

Proj. No.: ILLU-55-0303 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States.

Approach: Establish collection sites to give accurate and representative information, collectors will be of the wet/dry deposition type and dichomotous air-infiltration samplers. Analysis will be made on each sample: SO(4) , NO(3) , PO(4) iation during the study period. Deposition of a range of elements continues to be evaluated. At the DSAC location NO-(3) and NH+/(4) show the highest concentration on the average. The most significant input of these ions occurs during the spring and summer. Calcium, sodium, magnesium and potassium are deposited in lower concentration and generally in that order of importance. Monitoring continues at all locations.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

02.023* CRIS0074636
**CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION &
 EFFECTS ON AGRICULTURAL & FORESTED LAND &
 SURFACE WATER**

TABATABAI M A; Agronomy; Iowa State University, Ames, IOWA 50011.
 Proj. No.: IOW02276 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish an atmospheric deposition network. Determine the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to total deposition. Develop optimum procedures for collecting precipitation and dry particulate matter. Determine the stability of certain constituents of precipitation during collection, transport and storage prior to analysis. Investigate the transport and transformations of atmospheric constituents.

Approach: A network of precipitation collection sites will be established in the U.S. one of these sites will be in Central Iowa. Samples of precipitation and dry particulate matter will be collected at each site. The samples will be analyzed for SO(4) -, NO(3) -, PO(4) -, C1, NH(4) -, K -, Na -, Ca +, Mg +, pH, total and free acidity or alkalinity, and electrical conductivity. As the program develops, the analyses for heavy metals will be included.

Progress: 81/01 to 81/12. Rainfall collectors and measuring gauges were installed in 1978 at seven sites in Iowa. The sites are in Ames, the Agronomy farm in Boone County, Atlantic, Fairfax, Sigourney, Storm Lake, and Tripoli. Precipitation samples were collected on an event basis each year from May through November and analyzed for pH, conductivity, F -, C -, NH₄⁺/4, NO₃⁻/3, SO₄²⁻/4, PO₃⁻/4, K M Na -, Ca -, and Mg -. With exception of a few samples each year, the pH of the precipitation samples analyzed from the seven sites ranged from 5 to greater than or equal to 7, with the majority of the samples having pH value near 6. The most recent results (for 1983) showed that the pH values ranged from 4.1 of one sample collected at the Agronomy farm 7.4 of a sample from Storm Lake. The means and standard deviations of the pH values at the seven sites were: Ames, 5.9 +/- 0.5; Agronomy farm, 5.9 +/- 0.7; Atlantic, 6.7 +/- 0.2; Fairfax, 6.2 +/- 0.7; Sigourney, 6.7 +/- 0.3; Storm Lake, 6.2 +/- 0.5; Tripoli, 6.5 +/- 0.3. Expressed in mu g/ml, the mean values of NO(3)-N and SO(4)-S, respectively, were 0.5 and 1.0 (Ames), 0.4 and 0.9 (Agronomy farm), 0.7 and 1.4 (Atlantic), 0.8 and 2.3 (Fairfax), 1.4 and 2.5 (Sigourney), 0.7 and 1.0 (Storm Lake), and 0.5 and 1.3 (Tripoli). In general, the means of NH₄⁺/4-N concentrations were equal or slightly greater than those of NO₃⁻/3-N.

Publications: 81/01 to 81/12

- TABATABAI, M.A. 1982. Nutrient deposition by precipitation. Proceedings of a Public Conference. 120-140. Carroll University, University Heights, Cleveland, Ohio.
 TABATABAI, M.A. 1983. Atmospheric deposition of nutrients and pesticides. In F.W. Schaller and G.W. Bailey (eds.). Proceedings of the National Conference on

Agricultural Management and Water Quality, pp. 92-108.

SALEEM, H.B. 1983. Effect of pH on nitrogen mineralization and nitrification in soils. M.S. Thesis, Iowa State University, Ames. 110 p.

TABATABAI, M.A. 1984. Effect of acid rain on soils. CRC Crit. Rev. Environ. Cont. (In press).

LINZON, S.N., and TABATABAI, M.A. 1984. Soil-air pollutant interaction. In S.V. Krupa and A.H. Legge (eds.). Proceedings of the International Conference on Air Pollutants and Their Effects on Terrestrial Ecosystem. Wiley

02.024* CRIS0089151
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
 ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
 MATERIALS**

TABATABAI M A; Agronomy; Iowa State University, Ames, IOWA 50011.
 Proj. No.: IOW02601 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, rangelands, wetlands and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: We have seven precipitation sampling sites in operation in Iowa. Precipitation samples will be collected on event basis at these sites. The samples will be analyzed for pH, conductivity, NH (4), NO (3), C1, F -, SO (4), PO (4), K -, Na -, Ca -, and Mg -. The annual amounts of H and each of the nutrient elements added per unit surface area will be calculated. Contribution of atmospheric sulfur and other nutrients to crop requirement will be estimated.

Progress: 84/01 to 84/12. Rainfall samples were collected on an event basis at six sites (Ames, Atlantic, Fairfax, Sigourney, Storm Lake, and Tripoli) and on a weekly basis at the Agronomy Farm in Boone County in Iowa. A total of 177 samples were collected and analyzed analyzed for F,C1,NO3,S04,PO4,K,Na,Ca, and Mg The pH and conductivity of each sample ere also determined. The pH values ranged from 4.6 of one sample collected in Ames to 7.2 of a sample in Sigourney. The means and standard deviations of the pH values at the seven sites were: Ames, 6.1+0.5; Agronomy farm, 6.3 0.3; Atlantic, 6.6-0.4; Fairfax, 6.0+-0.6; Sigourney, 6.6+0.3; Storm Lake, 6.6+0.4; Tripoli, 6.6+0.3. Expressed in mg/L, the mean values of NO(3)-N and SO(4)-S, respectively, were 0.4 and 1.1 (Ames), 0.6 and 1.1 (Agronomy farm), 0.7 and 1.2 (Atlantic), 0.5 and 1.4 (Fairfax), 0.7 and

1.6 (Sigourney), 0.3 and 0.9 (Storm Lake) and 0.4 and 1.3 (Tripoli). Studies to evaluate the Dionex Model 10 Ion Chromatography (IC) for simultaneous determination of K, Na, Ca, and Mg in diverse types of natural waters, including rainfall and soil extracts, showed that the results by the IC method agreed closely with those obtained by flame photometry for K and Na and by atomic absorption spectrophotometry for K, Na, Ca, and Mg. The IC method is precise and accurate and can detect as little as 0.1 mg L of K, Na, Ca, or Mg in water samples. With the IC method, K and Na or Ca and Mg can be determined simultaneously in 2 mL of water in approximately 7 min.

Publications: 84/01 to 84/12

TABATABAI, M.A. 1985. Effect of acid rain on soils. CRC Crit. Rev. Environ. Cont. (In press).

TABATABAI, M.A. 1984. Importance of sulphur in crop production. Biogeochemistry 1:45-62.

BASTA, N.T., and TABATABAI, M.A. 1985. Determination of potassium, sodium, calcium, and magnesium in natural waters by ion chromatography. J. Environ. Qual. (In press).

02.025 CRIS0089127
AGGREGATION METHODS FOR ANALYSIS OF COMPLEX PUBLIC PROGRAMS

RANDALL A; HOEHN J P; Agri Economics; University of Kentucky, Lexington, KENTUCKY 40506.
 Proj. No.: KY00076 Project Type: HATCH
 Agency ID: CSRS Period: 01 DEC 82 to 30 SEP 85

Objectives: To identify the sources of error inherent in customary procedures for aggregating the benefits and costs of complex programs. To complete a theoretical analysis to define correct aggregation procedures. To develop empirical methods which implement, or approximate, correct aggregation procedures.

Approach: Specifications of the benefit aggregation problem, based on line integral concepts, suggest that the conditions under which customary aggregation procedures are correct are very restrictive. This work will continue, to more completely define the problem and to identify necessary and sufficient conditions for correct aggregation. Correct methods for benefit aggregation using contingent valuation methods will be defined. Aggregation of benefits estimated by methods based on market observations will be more difficult. Initial work will focus on competitive and complementary relationships among program components.

Progress: 84/01 to 84/12. In the last year, the research focus has shifted to developing operational methods of approximating the theoretically valid benefit aggregation structure identified in previous research. Initially, two operational structures were identified: a Cobb-Douglas structure that is very restrictive but has low information requirements and a Taylor Series Approximation

(TSA) that is flexible but requires much information. Current research focuses on a Restricted Elasticity Form of the TSA that is a little less flexible but also has less daunting information needs. A "cookbook" for approximately valid piecewise benefit aggregation using the REF has been developed and tested in the context of air and water pollution control programs. Working papers have been prepared. Work on companion projects funded by National Science Foundation and US Environmental Protection Agency is proceeding on schedule. Revision/extension of this project is pending.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

02.026 CRIS0075102
PALEOLIMNOLOGIC RECONSTRUCTION OF ACID PRECIPITATION EFFECTS ON DIATOMS & PH OF NEW ENGLAND LAKES

DAVIS R B; Botany & Plant Pathology; University of Maine, Orono, MAINE 04469.
 Proj. No.: ME08465 Project Type: HATCH
 Agency ID: CSRS Period: 01 MAY 78 to 30 SEP 84

Objectives: In six northern New England lakes, to determine if diatom communities have changed, and to infer from the changes the degrees and rates of change in lake water pH which may be due to atmospheric inputs of acids.

Approach: The diatom remains in sediment cores spanning the past 300 years will be studied. The study lakes are chosen to have watersheds with a history of minimal disturbance, so the effects of increased atmospheric pollution can be distinguished. Changes in pH will be inferred by applying coefficients (transfer functions) from regressions of diatom counts from lake surface sediments against lake pH (from numerous lakes in northern New England; data from other projects). Sediments will be dated by Pb-210 and pollen analyses.

Progress: 83/10 to 84/09. Five remote acidic lakes (now pH 4.5-5.0) in northern New England have been evaluated by analysis of their sediments to determine the history of lake water chemistry and air pollution in the past 300 years. Sedimentary remains of diatoms were used to infer water chemistry. This was supported by geochemical analyses. Sediment was dated by Pb and pollen chronostratigraphic markers. At two lakes, erosion (inferred from geochemistry) in the 1800's associated with lumbering (established from historical records) was coincident with mild eutrophication and increased pH to 5.5 (inferred from diatom remains). Lead, Zn, and Cu content of sediment started increasing about 150 years ago, indicating that long-distance transport of air pollutants began at an early date. Diatom-inferred acidification began at various dates between 1900 and 1940, depending on the lake. Acidification intensified in the 1950's. Pre-pollution inferred pH's (1600's and 1700's) were 4.7-5.3, indicating natural absence of bicarbonate alkalinity in these acid-sensitive

waters, and that the dominant anions were probably organic. While the acidification involved pH decreases of only about 0.5 pH unit or less, a fundamental shift in water chemistry can be inferred, rendering waters less suitable for fishes. Now SO_4^{2-} is the dominant anion, and inorganic, monomeric Al is more abundant than before. Calcium and Mn contents of sediment dating to the past 50 years have decreased. This is further evidence of acidification.

Publications: 83/10 to 84/09

- DAVIS, R.B. 1984. Paleolimnological reconstructions of lake acidification. Symposium: Topics in Historical Ecology. Univ. Fla., Gainesville. Dec.
- DAVIS, R.B. 1984. Tube coring. EPA workshop on paleolimnological studies of the history and effects of acidic deposition. Rockland, Maine. May.
- DAVIS, R.B. 1984. Chronostratigraphic markers. EPA workshop on paleolimnological studies of the history and effects of acidic deposition. Rockland, Maine. May.
- SWEETS, P.R., and DAVIS, R.B. 1984. Differential deposition and representation of diatom frustules in the surficial sediments of Jellison Hill Pond, Maine. 1984. AMQUA, Boulder, Colo. Aug.
- DAVIS, R.B., and ANDERSON, D.S. 1984. Inferring former lake-water pH from diatoms in Quaternary lake sediments. AMQUA, Boulder, Colo. Aug.

02.027 CRIS0094851 **EFFECTS OF ACIDIC DEPOSITION ON DIATOMS AND WATER CHEMISTRY**

DAVIS R B; Botany & Plant Pathology;
University of Maine, Orono, MAINE 04469.
Proj. No.: ME08450 Project Type: HATCH
Agency ID: CSRS Period: 18 JAN 85 to 17 JAN 87

Objectives: In six northern New England lakes the diatom remains in sediment cores spanning the past 300 years of deposit will be studied to document any changes in diatom communities, and to infer from such biological changes the degrees and rates of change in lake water chemistry (pH, organics, other) which may be due to atmospheric inputs of acids. To enlarge the present calibrational data set from 31 to 60 lakes. This should yield significant insight on the effects of "acid rain" on lakes in the region.

Approach: Diatom frustules are preserved in the sediment on the lake bottom. The pH tolerances of a large percentage of the commonly occurring taxa are known. This allows us to reconstruct changes in lake pH using sedimentary diatom analysis. We first develop calibrational regression equations relating lake water pH and other limnological factors to contemporary sedimentary (surface-sediment) diatom assemblages. The regression coefficients (transfer functions) may then be applied to older sediment (down-core) to infer past lake water pH and other factors.

02.028* CRIS0074811 **CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS**

NORTON S A; Geology; University of Maine, Orono, MAINE 04469.
Proj. No.: ME08904 Project Type: HATCH
Agency ID: CSRS Period: 01 JAN 78 to 30 SEP 83

Objectives: Establishing and Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States.

Approach: Locate an appropriate site for a precipitation collection station as part of a national network investigation regional trends in atmospheric deposition. Install equipment as specified for regional network. Collect and ship weekly samples to a Central Analytical Laboratory for chemical analysis of SO_4^{2-} , NO_3^- , PO_4^{3-} , Cl^- , NH_4^+ , K, Na, Ca, Mg, pH, total and free acidity or alkalinity, and electrical conductivity. pH and electrical conductivity will also be measured at the time of collection. Encourage participation of those organizations in the state of Maine with a vested interest in the quality of atmospheric precipitation.

Progress: 83/01 to 83/12. A precipitation station was established at Greenville, Maine as part of the National Atmospheric Deposition Program (NADP). The station was originally manned (in 1979 and early 1980) by the Maine Forestry Service and located on Maine Forestry land. In mid-1980 Mr. Llew Wortman, of the Moosehead Sanitary District, assumed responsibility for sample collection, collector maintenance and analytical field measurements. Weekly monitoring has been continuous since 1979. In 1980 Norton assisted in the site location selection for two additional NADP stations in Maine. In 1981, Mr. Wortman attended the National meeting of the NADP Technical Committee in St. Louis and in 1983 he attended a training session at Champaign-Urbana. Norton has, as station supervisor attended the yearly Technical Committee meetings of NC-141 since 1979. Since 1981, Norton has served as the NADP secretary and has consequently attended the bi-annual executive committee meetings.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

02.029* CRIS0089304 **CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, & MATERIALS**

NORTON S A; Geology; University of Maine, Orono, MAINE 04469.
Proj. No.: ME08904 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: (To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America). Specifically, to operate one (1) NADP precipitation collection station at Greenville, Maine. (To assess the effects of atmospheric deposition on the following: a) the productivity of forest trees, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife and fish, and c) the chemical composition of surface and ground waters.

Approach: Specific Projects under investigation in FY 83 at UMO include (as listed in the proposal), B1, 2, 6; C1; D2; E1, 2; G1, 2, 4; H1, 2, 3; I1, 2.

Progress: 83/10 to 84/09. The precipitation collection station has been in operation at Greenville, Maine for this past year which is part of the National Atmospheric Deposition Program. A cooperative agreement exists with Mr. Llew Wortman of the Moosehead Sanitary District facility at Greenville, Maine to operate the site. Mr. Wortman has carried out the sample collections, field measurements, and the shipping of samples to the analytical laboratory in Urbana, Illinois. Mr. Wortman and Dr. Fernandez implemented some improvements for the Greenville station this year which included (a) purchase of a new pH meter, (b) purchase of a new conductivity meter, and (c) relocation of the collector to improve the integrity of samples collected. The Greenville Station is now officially recognized as a site in both NADP and the National Trends Network. Dr. Fernandez participated in the annual technical committee meetings in Asheville, North Carolina and was elected vice chairman of the IR-7 Forestry Effects working group.

Publications: 83/10 to 84/09

- FERNANDEZ, I.J. Acid Deposition and Forest Soils: Potential Impacts and Sensitivity. In Adams, Donald D. and Walter Page (eds.). Acid Deposition Environmental, Economic, and Policy Issues. Plenum Press, NY (in press) BERNSTEN, C.M., CORLISS, J.F., FERNANDEZ, I.J., JOHNSON, D.W., JONES, H.C., III, SMITH, W.H. and LYONS, J.R. 1984. Report of the SAF Task Force on the Effects of Acidic Deposition on Forest Ecosystems. Society of American Foresters. FERNANDEZ, I.J. and CZAPOWSKYJ, M. 1984. Forest Floor Heavy Metals Levels in Low Elevation Commercial Spruce-Fir Stands in Maine. Agronomy Abstracts. Madison, Wisconsin p. 258

02.030 CRIS0085425
EFFECTS OF FOREST PRACTICES, SOILS AND PRECIPITATION ON WATER RESOURCES IN MASSACHUSETTS

MADER D L; College of Food & Natural Res.; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00043

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Assess effects of watershed characteristics, forest cover treatments and precipitation on streamflow. Establish criteria for water quality levels in relatively undisturbed watersheds. Develop computer models to predict effects of treatment alternatives on water yield.

Approach: Continuation of research on streamflow initiated under MS-2 using five stream-gauging stations established on Cadwell creek in Cadwell Research Forest. Weekly water samples for complete chemical analysis. The Brook Watershed Model compared with Cadwell computer Model.

Progress: 83/10 to 84/09. Analysis of low density white pine study plots established in 1962 was completed, including volume and basal area growth, and economic analyses. Results demonstrate the soundness of this management option for plantations on watersheds. Low density plots exhibited much larger sizes and quality of stems after 20 years, much earlier merchantability, and very high board foot volumes. Economic analysis indicated substantial benefits in terms of timber values from the treatments, augmenting early gains in reduced transpiration. Stream-flow and water quality monitoring of the Cadwell Creek Watershed were continued in conjunction with the acid deposition (NADP) monitoring program. The data contributes to the national and state acid rain studies. A paper on stream water condition in relation to acid deposition has been submitted for publication. A study of chemical properties of rainfall and throughfall in sugar maple stands on several soils, to examine canopy/rainfall interactions is near completion.

Publications: 83/10 to 84/09

- STONE, R. J. 1984. Low density white pine management. M.S. Thesis, University of Mass., Amherst.

02.031* CRIS0084716
THE LIMNOLOGICAL IMPACT OF ACID RAIN ON FARM PONDS

COLER R A; Environmental Science; University of Massachusetts, Amherst, MASSACHUSETTS 01003.

Proj. No.: MAS00511 Project Type: HATCH
 Agency ID: CSRS Period: 11 JUN 81 to 30 SEP 84

Objectives: Trace the impact of acid rain percolating through glacial till utilized for pasture and forestry on lake dynamics. Identify critical parameters as early warning indices of acid-rain stress on lotic systems.

Approach: Logically, an ecological study is a field study, but the problem of obtaining replicates and maintaining controls would be logistically unmanageable. Consequently, the applicant proposes to monitor, with a laboratory model over an extended period, the changes that unfold from the deposition of acid rain directly on the "pond" surface and as a subsurface accrual.

Progress: 83/10 to 84/09. The effect of acid rain and elevated aluminum on the dragonfly has been to reduce respiration and the excretion and accumulation of metabolites. Investigations of feeding and starved specimens indicate that these stresses disrupt ingestion absorption or assimilation rather than intermediate metabolism. The significantly depressed energy availing processes will likely cause a diversion of energy from growth moulting and emergence. While the dragonfly regulates its internal environment, the caddisfly seems to conform to the external environment. No homeostatic mechanism could be clearly identified. On the basis of this one detritive, themechanical breakdown of detritus doesn't seem to be imperiled by acid rain or acid rain and aluminum. While excretion did measurably increase, respiration did not.

Publications: 83/10 to 84/09

- CORREA, M., CHIH-MING, R.A., CHIH-MING, Y. 1984. Changes in oxygen uptake and nitrogen metabolism in the dragonfly *Somatochlora cingulata* exposed to aluminum in acid waters. *Hydrobiologia* in press.
- MEDEIROS, C., COLER, R. and CALABRESE, E. 1984. A laboratory assessment of the toxicity of urban runoff on the fathead minnow (*Pimphales Promelas*). *J. Environ. Sci. Health*, A19(7), 847-861.
- TEASE, B. and COLER, R. 1984. The Effect of Mineral Acids and Aluminum from Coal Leachate on Substrate Periphyton Composition and Productivity. *J. Freshwater Ecology*, Vol. 2, No. 5 August.

02.032 CRIS0076420
EVALUATION OF BIOCHEMICAL INDICATORS, FOR ASSESSMENT OF AGRICULTURAL CONTAMINATION OF WATER

LITSKY W; WALKER R W; Environmental Science; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00447 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 78 to 30 SEP 83

Objectives: value of 5B-cholestan-3B-01 (coprostanol) or determinant of fecal pollution of H(2)O. Feasibility of a biological-chemical method of assessing aquatic contamination. Improve analytical procedures for simultaneous extraction of phytoplankton chlorophylls and coprostanol.

Approach: Develop a sensitive and reliable procedure for identifying and measuring coprostanol in the environment. Establish baselines and determine if the fecal excreta of man and higher animals is or is not the only significant source of this sterol.

Progress: 82/10 to 83/09. The toxic effects of heavy metals upon blue-green algae was studied further. The preliminary studies which commenced with support from this project will be continued as Hatch 560. This project will be concerned with an in depth look at the role of blue-green algae in the dynamics of heavy metals in freshwater systems. Our first approach has been to determine the role of the

sheath in this group of organisms remarkable heavy metal bioconcentrating ability. Gloeotheca strains (sheathed and a sheathless mutant) from the Pasteur Institute are being used in this study. Our second approach will be to characterize the sheath chemically. Preliminary experiments have shown the sheath isolated and purified from *Chroococcus parisi* (a *Gloeotheca* species) to be composed of several sugars (glucose, mannose and others), a uronic acid and protein.

Publications: 82/10 to 83/09

- LES, A. and WALKER, R.W. Toxicity and binding of copper, zinc and cadmium by the blue-green alga, *Chroococcus parisi*, in press, *Water, Air and Soil Pollution*.

02.033* CRIS0082978
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS & MATERIALS

FEDER W A; CRAKER L E; Suburban Exper Station; University of Massachusetts, Waltham, MASSACHUSETTS 02154.
 Proj. No.: MAS00496 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils.

Approach: In addition to maintaining 2 NADP/IR7 collection sites, studies of the plant/soil/air rainfall interactions will be made to discover if atmospheric deposition predisposes plants to injury by foliar or root pathogens/pests and if plant injury is enhanced or reduced by inter-actions between atmospheric deposition and other air pollutants like ozone, sulfur dioxide, and/or particulate matter. The effects of changes in soil chemistry from atmospheric depositions upon mycorrhizal and nitrogen fixation organisms will be examined. The changes in soil chemistry due to atmospheric deposition will be studied for their effects on the mobilization of toxic elements like Al and the subsequent effects of released aluminum upon aquatic ecosystems. The movement of trace heavy metals from atmospheric deposition through terrestrial ecosystems will be followed and the effects quantified.

Progress: 83/10 to 84/09. Continued to operate wet/dry collectors for NADP network. Also participated in state-wide survey of aquatic lake/pond/stream pH values and fairly high alkalinity values, indicating little rainfall effect upon pH of aquatic areas surveyed. Soil solution pH rather than rainfall pH controlled movement of heavy metals through two soil types. Agriculturally, soil chemistry and soil solution chemistry will regulate the magnitude of the acid rainfall effect on plants growing in any soil. This seems to confirm the fact that crop plants growing in good agricultural soils properly cared for culturally will not be adversely affected by acid precipitation, per se. It is important to appraise farmers of this information, while at

same recognizing that the action of acid rainfall over forest ecosystems may have a different impact, of which to date, we have little understanding. This project will be continued under a new Hatch Project Number, as of October 1, 1984.

Publications: 83/10 to 84/09

MIKA, J. S. and WILLIAM A. F. 1984. The movement of incinerator fly ash and residue-generated Cd, Pb and Zn through soil columns leached with acid precipitation, APCA Northeast Atlantic International Section Technical Meeting.

02.034* CRIS0074631
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

HART J B; Forestry; Michigan State University, East Lansing, MICHIGAN 48824.
 Proj. No.: MICLO1282-H Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 28 DEC 84

Objectives: Establishing an Atmospheric Deposition Network to determine special & temporal trends in the supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter deposited in various regions of the United States. Organizing and coordinating research in the SAES, FS, and other research institutions & agencies on the effects of changes in atmospheric deposition on: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters: The health & productivity of domestic food animals, wildlife, and fish; and the corrosion of metals, painted surfaces, masonry, and other materials in machinery or structures.

Approach: Establishment of two monitoring sites in Michigan. Weekly analysis of collected precipitation & dry particulates. Use trends to find effects on forest growth & reproduction.

Progress: 83/01 to 83/09. Research activities were pursued in this project prior to initiation of Project IR-7. Two wet-dry deposition monitoring sites are maintained as part of the National Atmospheric Deposition Program network and National Trends Network: one at Kellogg Biological Station in southwest lower Michigan; and one at the University of Michigan Biological Station in north central lower peninsula Michigan. Precipitation acidity has ranged from extremes of 3.8 to 7.2 with a normal range of 4.2 to 5.7. Simulated acid precipitation of pH 2.5 and below adversely affected greenhouse germination and survival of jack pine. Foliar necrosis and stem lesions were produced on seedlings grown at pH 3.0 and below. Preliminary results indicate episodic simulated acid precipitation of pH 3.0 has no significant effect on survival, growth, or foliar appearance of one-year old jack pine seedlings or competing species of *Carex* sedge. Interpretation of the monitoring network results using information from previous research indicate that neither the extremes or normal acidity ranges are sufficient to preclude the germination and early development

of *Pinus banksiana* on typical Udipsamment soils of the region.

Publications: 83/01 to 83/09

MACDONALD, N.W. 1983. The effects of simulated acid precipitation on regeneration and soils in the Jack pine-Grayling sand ecosystem. M.S. Thesis. Michigan State University, E. Lansing, 189p.

02.035* CRIS0091453
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

HART J B; Forestry; Michigan State University, East Lansing, MICHIGAN 48824.
 Proj. No.: MICLO1447 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To access the effects of atmospheric deposition on a) productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife, and fish; c) the chemical composition of surface and ground waters; and d) atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Deposition sites will be instrumented and maintained in specific ecosystem strata occurring in Michigan according to IR-7/NADP protocol. Regional and network evaluation of monitoring data will be conducted. Effects of past, present and potential atmospheric deposition will be studied by vegetative, soil and hydrologic components. Statistically designed experiments and sample collections will be conducted on important components of individual ecosystems, and groups of systems, to test hypothesized effects and quantify relationship. These studies, where appropriate, will be conducted in cooperation with other states and regions. Biologically and economically feasible strategies for control and treatment of atmospheric deposition effects will be developed from these results.

Progress: 84/01 to 84/12. Two wet-dry deposition monitoring sites were maintained as part of the National Atmospheric Deposition Program network and National Trends Network: one at Kellogg Biological Station in southwest lower Michigan; and one at the University of Michigan Biological Station in north central lower peninsula Michigan. Precipitation acidity has ranged from extremes of 3.8 to 7.2 with a normal range of 4.2 to 5.7. Evaluation of the monitoring network results and recent research on *Pinus banksiana* regeneration indicate that neither the extremes or normal acidity ranges are sufficient to preclude the germination and early development of jack pine forests on typical Udipsamment soils of the region. Approximately 40% of Michigan soils have been determined to

be sensitive or slightly sensitive using published criteria. Most are predominately forested soils. Current research is reevaluating the sensitivity of Michigan and Upper great lakes forested soils to atmospheric deposition and the long-term effects of nutrient depletions and acidification.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

02.036 CRIS0000153
WATER QUALITY MANAGEMENT IN FORESTS OF THE
WESTERN GREAT LAKES REGION

KNIGHTON M D; Forestry Sciences Laboratory;
 North Central Forest Expt Stat, Grand Rapids,
MINNESOTA 55744.
 Proj. No.: NC-1602 Project Type: INHOUSE
 Agency ID: FS Period: 26 NOV 84 to 26 NOV 89

Objectives: To evaluate the impact of acid rain on the soil and water resources of the western Great Lakes region; to evaluate the impact of forest management practices on surface water quality in the western Great Lakes region; and to develop guidelines for environmentally sound uses of natural peatlands for sewage treatment and disposal.

Approach: Acid rain studies will determine the composition of regional precipitation (four NADP-NTN sites); the subsequent effects of vegetation and soil types on soil water and runoff water chemistry (six sites); and final effect on regional lake water chemistry. Forest fertilization and forest harvesting methods and intensities will be assessed for effects on water quality using paired watershed and replicated plots on three soil types. Sewage effluent will be applied to plots in a peatland to determine loading capacity of N and P.

Progress: 83/10 to 84/09. A hummock-hollow level survey of a small Minnesota mire was used to refine the definition of acrotelm and catotelm. The division between these two peat profile layers can be determined more objectively. Regrowth of sphagnum moss on a harvested peatland in east central Minnesota accumulated at 3.9 t/ha/yr. Twenty years of regrowth would return the site to pre-harvest sphagnum biomass. In water impoundments drawdowns do not impair downstream water quality nor do they "rejuvenate" nutrients in the reflooded water. Plant community changes are explained by water level regimes and inherent water quality. Anaerobically digested municipal sludge can be applied to red pine and white pine plantations at 16.5 dry Mg/ha or less and to aspen sprouts at rates up to 19 dry Mg/ha without exceeding 10 μ eq/l potability standards in groundwater. Addition of wastewater sludges to pine plantations growing on nutrient-poor outwash soils has increased concentrations of N and P in upper soil layers and enhance the short-term growth of understory and overstory vegetation.

Publications: 83/10 to 84/09

VERRY, E.S. 1984. Microtopography and water table fluctuation in a sphagnum mire. In: Proc., 7th International Peat Congress; June 18-23, 1984, Dublin, Ireland. Dublin, Ireland: The Irish National Peat Committee, 2:11-31.

ELLING, A.E. and KNIGHTON, M.D. 1984. Sphagnum moss recovery after harvest in a Minnesota bog. J. Soil and Water Conserv. 39(3):209-210.

VERRY, E.S. 1983. Water quality dynamics in shallow water impoundments of North Central Minnesota. Ph.D. Thesis. Colorado State University, Ft. Collins, CO; 150p.

BROCKWAY, D.G. and URIE, D.H. 1983. Determining sludge fertilization rates for forests from nitrate-N in leachate and ground water. J. Environ. Qual. 12(4):487-492.

BROCKWAY D.G. 1983. Forest floor, soil, and vegetation responses to sludge fertilization in red and white pine plantations. Soil Sci. Soc. Am. J. 47:776-784.

02.037 CRIS0088732
PREDICTIVE MODELS OF WATER QUALITY IMPACTS FROM
SELECTED ENVIRONMENTAL MANAGEMENT ALTERNATIVES

PERRY J A; Forest Resources; University of Minnesota, St Paul, **MINNESOTA** 55108.
 Proj. No.: MIN-42-025

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 NOV 82 to 30 SEP 86

Objectives: Develop bivariate and multivariate models relating water quality of small streams to environmental management practices. Test several hydrologic modeling alternatives such as paired watersheds, upstream/downstream stations, stream segment ecosystems, and multiple watersheds. Assemble, catalogue and automate access to literature relating environmental management to stream water quality. Develop and document a rationale for water quality monitoring plans.

Approach: Investigate the relationship between stress quality, wetland function, and precipitation chemistry and the relationship between organic matter and geomorphology. Determine the potential value of those relationships as predictors of water quality under different management strategies and precipitation quality regimes. Compile an indexed bibliography of recent cold spring literature.

Progress: 84/01 to 84/12. (1) Water quality is an integral part of overall watershed resource assessment and management. Accurate and defensible watershed management decisions require a solid base in a disciplinary perspective, and an involvement of scientists from a series of disciplines. This is especially true in areas with a complex of forest and agricultural land use. (2) This project if designed to provide the water quality element of integrated interdisciplinary watershed management efforts. To that end, we have pursued specific projects which provide the base for the detection of impacts, and

interdisciplinary projects which provide the integration. In the former category are works on the cycling of carbon and phosphorus in aquatic systems, innovative tools for measuring biology impacts, and effects of acid deposition on lower trophic levels. These elements all seek to provide answers to the question: what are the specific impacts of alternative water quality management strategies? (3) The interdisciplinary integration is provided through several team approaches to water resource management; e.g., a team evaluation of Thai watershed management, a team approach to water quality management in Southeast Minnesota, and pending watershed work in India and other parts of Asia.

Publications: 84/01 to 84/12

- PERRY, J.A., SCHAEFFER, D.J., KERSTER, H.K. and HERRICKS, E.E. 1984. The environmental audit II: Application to stream network design. Environmental management, In Press.
- PERRY, J.A. 1984. The Dillor Hypothesis of Titular colonicity: An empirical test from the ecological sciences. Journal of the American Society for Information Science, In Press.
- PERRY, J.A. 1984. Preliminary design of a water quality monitoring exercise with simulated historical records. Journal of the National Association of College Teachers of Agriculture. 28(4)20-22.
- SCHAEFFER, D.J., KERSTER, H.K., PERRY, J.A., SOKOLIK, S.K. and COX, D.K. 1984. The environmental audit I: Concepts. Environmental Management. In press.
- PERRY, J.A. 1984. No Halo for HALO and SURF is not golden: A review of two graphics packages. Science Software Quarterly 1:64-73.

various man-made and natural sources through the atmospheric and are deposited on plant, animals, soils and surface waters. The work of this Network will be developed in parallel with the related Canadian Network for Sampling Precipitation (CANSAP).

Progress: 84/01 to 84/12. Chemical characteristics of aerosol and rain samples collected at five sites in Minnesota during the summer of 1982 were generally similar in regard to the relative proportions of major constituents. On a mass basis, sulfate was the predominant component in the fine particle (<2.5 μ m) fraction. The concentrations of crustal materials in both the aerosol and the rain followed a gradient in which concentrations increased with proximity of the sampling site to the prairie. The concentrations of the crustal materials in the aerosols were correlated with their concentrations in subsequent rain, whereas concentrations of other constituents were not significantly correlated between aerosol and rain. Nitrates and crustal materials were removed more effectively by both wet and dry mechanisms than ammonium, sulfate and other constituents occurring predominantly in the fine fraction. The components in the aerosols were divided by factor analysis into: ammonium sulfates, crustal materials.

Publications: 84/01 to 84/12

- GUIANG, S.F., KRUPA, S.V. and PRATT, G.C. 1984. Measurement of S(IV) and organic anions in Minnesota rain. Atmos. Environ. 18:1677-1682.
- PRATT, G.C. and KRUPA, S.V. 1985. Aerosol chemistry in Minnesota and Wisconsin and its relation to rain chemistry. Atmos. Environ. (In press).

02.038 CRIS0078453
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

KRUPA S V; Plant Pathology; University of Minnesota, St Paul, MINNESOTA 55108.
 Proj. No.: MIN-22-080 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetland and soils.

Approach: This objective will be achieved by further developing and maintaining the NC-141/NADP atmospheric chemical deposition network and related local networks. The Program will determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in both wet and dry deposition in various regions of the United States. The Program will also describe the atmospheric processes by which essential nutrients, strong acid and acidifying substances, toxic metals, and other beneficial and injurious substances are transferred from

02.039* CRIS0089150
CHEMISTRY OF ATMOSPHERIC DEPOSITION: EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, & MATERIALS

HENDERSON G S; Forestry Fisheries & Wildlife; University of Missouri, Columbia, MISSOURI 65211.
 Proj. No.: MD-00163-1 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, range lands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints, and other productivity coatings, and other material in machinery or structure.

Approach: NADP monitoring stations are presently established at University Forest near Poplar Bluff and at the Ashland Wildlife Area. These collection stations will continue to be

operated with samples analyzed to characterize the chemistry of rainfall in Missouri. Additional research will be conducted on soil fertility as affected by acid deposition. Plots which have received quarterly additions of accelerated acid inputs will be used in this study. Base status and nitrogen transformations will be most intensively studied.

Progress: 84/01 to 84/12. Precipitation monitoring at two NADP stations was continued in Missouri. The data from these stations continue to show that Missouri's precipitation is acid with a pH averaging between 4.5 and 4.6. Chemical analyses on the samples further indicate that the precipitation is dominated by sulfate with lesser amounts of nitrate. Soil in plots which have been artificially acidified for the past two years were sampled and subjected to analysis. No significant changes in soil acidity were observed among the different acidity treatments. This experiment is being continued and soil will be sampled again next spring. A major research project designed to evaluate the effects of soil aluminum on tree root growth was installed this year. The study utilizes root ingrowth cores constructed from soil treated as as to create a wide range of extractable aluminum concentrations to quantify root growth changes. The study is being conducted at three sites with three vegetation types: Oak-Hickory in Missouri, Loblolly Pine in Mississippi, and a northern hardwoods - spruce - hemlock mixture in New York.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

02.040 CRIS0096493
**PRINCIPLES AND ALTERNATIVES IN U.S.-CANADIAN
NEGOTIATIONS ON ACID RAIN**

CONRAD J M; Agri Economics; Cornell University, Ithaca, **NEW YORK** 14853.
Proj. No.: NYC-121431 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 88

Objectives: To examine the implicit principles underlying the negotiation and treaties between the U.S.A. and Canada relative to transboundary resource and pollution disputes, to determine how such principles, existing law and institutions might influence the negotiations, treaties, and control of acid rain, to determine the form of direct control or economic incentives which are both feasible politically and effective economically.

Approach: Review and synthesize the relevant history of U.S.-Canadian relations on transboundary resource and environmental problems, adapt an existing model or construct a new model to simulate industry response to alternative controls or economic incentives to reduce SO₂(2) emissions.

02.041 CRIS0065152
CHEMICAL NUTRITION OF AQUATIC MACROPHYTES

PEVERLY J H; Agronomy; Cornell University, Ithaca, **NEW YORK** 14853.
Proj. No.: NYC-125420 Project Type: HATCH
Agency ID: CSRS Period: 05 OCT 82 to 30 SEP 86

Objectives: To measure cation (K, Al, Ca) content of plant, water, and sediment phases for lakes and ponds with a variety of chemical regimes. To determine importance of root and shoot absorption for these cations. To determine roles of cations (H, K, Al, Ca) in growth and nutrition of aquatic plants.

Approach: Associations of high tissue cation contents with other nutrients, with sediment and water concentrations, and with certain plant growth characteristics will be used as a basis of experimentation at the field and laboratory level. These experiments will confirm the evidence of cation roles in nutrition of macrophytes under a range of chemical regimes and growth habit. Examination of physiological response will increase our ability to predict reactions to changing environments.

Progress: 83/01 to 83/12. Field studies of both hard-water (Otsego Lake, NY) and soft-water (Adirondack) macrophyte communities indicate that aquatic plant growth may be limited by P or K, while tissue N is generally present in sufficient quantities for normal development. Samples of water, pore water, sediment, and plant tissues from acidic soft-water lakes had considerably higher Al concentrations than did samples from neutral soft-water lakes. Laboratory studies were designed to investigate the effects of low pH and increased Al concentrations of growth of *Eriocaulon septangulare*, a common species in these soft waters. Results obtained thus far show that *Eriocaulon* utilizes free CO₂(2) and not bicarbonate (HCO₃ / (3) as a carbon source; data on carbon fixation rates are being analyzed to determine compensation point and saturation values of CO₂(2). Experiments conducted to detect Al toxicity are not complete but results suggest that effects, if any, are indirect through its effects on P availability or metabolism, rather than direct. Relationships between Al and phosphorus metabolism in *Eriocaulon* will be investigated in laboratory experiments during the next year. Field and laboratory studies have been funded in part through grants from the A.W. Mellon Foundation to Dr. G.E. Likens (Institute for Ecosystem Studies, New York Botanical Garden, Carey Arboretum, Millbrook, New York).

Publications: 83/01 to 83/12
BEST, M.D., and PEVERLY, J.H. 1983. Aquatic vegetation in Adirondack Lakes: Field observations and experiments with pH, DIC, and Al. pp. 71-78. In: C.D. Collins (Ed.) The Lake George Ecosystem, Vol. III. The Lake George Association.
BEST, M.D., and PEVERLY, J.H. 1982. Responses of aquatic vegetation to increased aluminum in acidified waters. Agronomy Abstracts, 1982:25.

BEST, M.D., and PEVERLY, J.H. 1982. Water and sediment chemistry and elemental composition of macrophytes in fifteen Adirondack Lakes. pp. 77-80. In: J.S. Jacobson (Ed.), Proc. N.Y.S. Symposium on Atmospheric Deposition.

02.042* CRIS0087659
CHEMICAL PROCESSES CONTROLLING INTERACTIONS BETWEEN ACID PRECIPITATION AND FOREST SOILS

RIHA S J; JAMES B R; Agronomy; Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-125555

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 JUL 82 to 30 SEP 86

Objectives: Measure changes in the ionic composition of the solution of various horizons of acid forest soils; explain these effects with respect to chemical mechanisms controlling the solubility of various ions; test our hypotheses by selecting soils which on the basis of previous experiments we would expect to respond differently with soils which on the basis of previous experiments we would expect to respond differently with respect to Al and base leaching after input of strong acids at the surface and subject whole soil profile columns to leaching with strong acids.

Approach: Based on hypotheses developed from the behavior of mineral acids added to organic horizons studied under controlled experimental conditions, similar in-depth experimental approaches than will be used to learn what further reactions occur in the lower horizons. After observing changes in solution and soil chemistry with depth and elucidating possible mechanisms to explain the changes, whole soil profiles will be reconstructed in columns and used to test the combined hypotheses derived from the study of each horizon separately.

Progress: 84/01 to 84/12. Initial research aimed to identify changes in the equilibrium solution chemistry of organic surface horizons of 6 forest soils acidified with 0 to 20 cmol H kg soil under controlled laboratory conditions. Previous experiments had demonstrated no differences between the effects of HNO₃ and H₂SO₄ on the solution composition of these organic horizons. The proton buffer capacity of these horizons ranged from 17 to 34 cmol H kg pH unit. The high Ca saturation of exchange sites (93-218%) resulted in the predominance of H for Ca exchange upon acidification of horizons. In contrast, the concentrations of Mg, K and Mn changed relatively little upon acidification. Basic cations were not replaced by H on an equivalent basis but only accounted for 14 to 62% of the proton buffering. Protonation of soluble and solid phase weak acid functional groups also appeared to contribute significantly to proton buffering. In these surface organic horizons, soluble Al generally was less than 1% of the cations in solution on an equivalent basis. Changes in soluble Al upon acidification indicated that nonlabile and labile forms of Al can increase, decrease or not change. Nonlabile complexes were the dominant forms of soluble Al

in organic surface horizons above pH 4. Labile Al comprised an increasing percentage of total Al as pH decreased, especially below pH 3. Results indicated that pH alone was a poor predictor of total and nonlabile Al in solution, but a better predictor of the ratio of soluble carbon-to-Al.

Publications: 84/01 to 84/12

JAMES, B.R. and RIHA, S.J. 1985. Soluble aluminum in acidified organic surface horizons of forest soils. Can. J. Soil Sci. In press.

02.043 CRIS0089207
WATER AND NUTRIENT FLUXES IN LODGEPOLE PINE FORESTS IN WYOMING

FAHEY T; KNIGHT D; Natural Resources; Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-147338 Project Type: STATE
 Agency ID: SAES Period: 01 OCT 82 to 30 SEP 85

Objectives: To quantify the rate and mechanism of dry deposition on leaf surfaces. To evaluate the magnitude and pathway of water movement through soil macropores and the role of this process in affecting solute concentrations in subsurface outflow. To characterize organic solutes in ecosystem solutions.

Approach: Field and laboratory methods will be utilized. Dry deposition will be quantified using surrogate surface, branch chambers, and empirical modelling. Macropore flow will be examined by flooding techniques utilizing neutron thermalization and zero-tension lysimetry. Organic solutes will be characterized by standard wet chemistry methods, coalimetry, liquid chromatography and gas-liquid chromatography. Results will be integrated for publication in refereed journals.

Progress: 84/01 to 84/12. Currently, we are developing simulation models to predict the effects of environmental variation (soils and meteorology) and natural and human perturbation (forest fire, bark beetle epidemics, clear-cutting) on water and nutrient fluxes in lodgepole pine ecosystems. These models are being developed using our extensive information base on ten forest stands. Recent simulation analyses indicate that 10% to 30% of snowpack water may be diverted from the streamflow pathway by forest evapotranspiration in spring. Total water outflow may vary by 3 to 4-fold between lodgepole pine ecosystems of different structure. These ecosystems appear to be very well-buffered against acid rain because of abundant acid neutralization capacity in forest floor and soil. Finally, nitrogen loss from these systems (as nitrate) is markedly increased (over 10-fold) during the second and third year following natural and simulated bark beetle epidemics.

Publications: 84/01 to 84/12

FAHEY, T.J., and YOUNG, D.R. 1984. Soil and xylem water potential and soil water content in contrasting Pinus contorta ecosystems, southeastern Wyoming, USA.

Oecologia (Berl.) 61:346-351.

PEARSDN, J.A., FAHEY, T.J., and KNIGHT, D.H. 1984. Biomass and leaf area in lodgepole pine forests of different structure. Can. J. For. Res. 14:259-265.

YAVITT, J.B. and FAHEY, T.J. 1984. An experimental analysis of solution chemistry in a lodgepole pine forest floor. Dikos 43:222-234.

02.044 CRIS0070504
EFFECTS OF ACID PRECIPITATION ON ADIRONDACK LAKES

SCHOFIELD C L; GLDSS S P; WEBSTER D A; Natural Resources; Cornell University, Ithaca, NEW YORK 14853.

Proj. No.: NYC-147321 Project Type: STATE
Agency ID: SAES Period: 01 OCT 84 to 30 SEP 87

Objectives: To investigate lake and stream sensitivity to acidification by acid precipitation and determine the mechanisms which lead to chemical and biological changes. To evaluate and develop procedures for restoring and maintaining fisheries in acidified lakes.

Approach: Mechanisms of aluminum mobilization and transport to stream ecosystems and the biological effects of this acidification related process are being investigated at calibrated watershed sites in the eastern U.S. and Canada. Fish and invertebrate population responses to temporal and spatial acidification gradients within streams are being evaluated in the Adirondack Mountain streams. A pilot scale liming program (ELS, USFWS supported) was initiated on 10 Adirondack lakes in 1983. Limestone dose/alkalinity response functions, treatment longevity in relation to basin hydrology and morphometry, survival of stocked brook trout populations, and effects of neutralization on aluminum speciation and toxicity to trout are being evaluated. A companion lake liming study (LAMP, EPRI supported) was initiated on 3 Adirondack lakes to provide more detailed ecosystem level response data.

Progress: 84/01 to 84/12. Results of the ILWAS field program and lake acidification model development were summarized and submitted for publication as a series of papers in Water, Air, and Soil Pollution. Major findings of this four year field study of three Adirondack lake-watershed systems were: A primary determinant of lake alkalinity and sensitivity to acidification is the relative distribution of water inputs routed through shallow soil interflow and deeper, groundwater flow paths. Episodic acidification results from an upward shift in flowpaths from ground water dominated base flow to shallow interflow during increased snowmelt discharge. Increased acidity levels and aluminum mobilization during these events are triggered by increased nitric acid output and base cation dilution, relative to ambient sulfate levels. Model simulation of a 50% reduction in total atmospheric sulfur inputs indicated that significant decreases in acidity of sensitive Adirondack lake types would occur.

Two lake neutralization studies were initiated in 1983 to evaluate the effects of liming and subsequent re-acidification on fish and invertebrate populations. Ten Adirondack lakes were treated and stocked with two strains of brook trout in 1983-84, to serve as a pilot scale evaluation of liming and the use of acid tolerant trout strains for rehabilitation of acidified Adirondack lakes.

Publications: 84/01 to 84/12

GIBSDN, J.N., GALLDWAY, J.N., SCHDFIELD C., McFEE, W., JOHNSDN, R., McCARLEY, S., DISE, N., and HERZDG, D. 1983. Rocky Mountain Acidification Study. U.S. Fish and Wildlife Service, Division of Biological Services.

SCHDFIELD, C.L. 1984. Surface water chemistry in the ILWAS basins. In: The Integrated Lake-Watershed Acidification Study Vol. 4: Summary of Major Results. R.A. Goldstein and S.A. Gherini, editors. EPRI Report EA-3221, pp.

SCHDFIELD, C.L. 1984. Effects of acid deposition on aquatic systems. In: Acid precipitation in relation to agriculture, forestry, and aquatic biology. C.A. Black, editor. CAST Report No. 100, 31 pp.

BAKER, J.P. and SCHOFIELD, C.L. 1984. Acidification impacts on fish populations: A Review. In: Acid Deposition: Environmental and Economic Impacts. D. Adams and W. Page, Editors. Plenum Publ. Co., NY (in press).

SCHDFIELD, C.L., GLDSS, S.P., and JOSEPHSON, D. 1984. Extensive evaluation of lake liming, restocking strategies, and fish population response in acidic lakes following neutralization by liming.

02.045 CRIS0091189
PALEOECOLOGICAL STUDY OF EFFECTS OF LAKE ACIDIFICATION ON CHIRONOMID COMMUNITIES

MITCHELL M J; School of Biology Chem & Ecol; State University of New York, Syracuse, NEW YORK 13210.

Proj. No.: NYZ-2222-01-007 Project Type: STATE
Agency ID: OCI Period: 01 MAY 83 to 31 DEC 85

Objectives: To examine the extant benthic communities in series of lakes with different pH levels from the Adirondack mountain region. To examine the stratigraphy of chironomid head capsule remains in sediments for assessing the time frame of acidification and its effects on chironomid communities. To synthesize study results with concomitant studies on the same lakes which are examining watershed geology and vegetation, water chemistry and the stratigraphy of chemical constituents and diatom remains.

Approach: Ten Adirondack lakes with a range of pH conditions will be examined for chironomid remains. Extant benthic communities will be analyzed using core samples, a dredge sample, taxa identification, and sample dating in these lakes and an additional ten lakes for calibrating the effect of water chemistry on the chironomid community.

Progress: 83/10 to 84/09. We are examining the stratification of chironomid head capsule remains in the recent sediments of seven Adirondack lakes. Temporal changes in chironomid community structure which have occurred during the last 200 years are being related to acidification and other watershed disturbances. The extant chironomid communities of the seven lakes, plus 13 additional lakes are also being sampled. The extant data are providing additional information on how chironomid communities vary with pH, which will aid in interpreting the stratigraphic profiles. The data available to date indicate that acidification has not caused drastic changes in chironomid community structure. The dominant taxa appear to be eurytopic and are not strongly, if at all, affected by increased acidity. Some of the less abundant taxa appear to be useful indicators of acidification. For example, the chironomid stratigraphy of Deep Lake (present pH = 4.6) shows changes which are indicative of acidification beginning after 1930. This corresponds well with the diatom stratigraphy of Deep Lake, which indicates a pH reduction beginning after 1940.

Publications: 83/10 to 84/09
NO PUBLICATIONS REPORTED THIS PERIOD.

02.046 CRIS0085604
MEASUREMENT OF PRECIPITATION AT THE HUNTINGTON WILDLIFE FOREST

RAYNAL D J; Biology Chemistry & Ecology; State University of New York, Syracuse, NEW YORK 13210.

Proj. No.: NYZ-2226-01-008 Project Type: STATE
Agency ID: OCI Period: 06 JUN 80 to 31 MAY 86

Objectives: This project is designed to gather precipitation samples and dry deposition samples in the Central Adirondack Mountains as part of the precipitation monitoring network of the National Atmospheric Deposition Program (NADP). Supporting weather information will also be amassed. The information collected will support the college's efforts determining the actual and potential effects of acid precipitation on certain Adirondack forest ecosystems. The project will also result in an improved basis for evaluating the dynamic nature of precipitation chemistry in the Central Adirondack region.

Approach: Precipitation samples will be collected weekly and dry deposition samples bimonthly on a year-round basis using the Aero-Chem Metrics Model 201 precipitation sampling apparatus. Samples will be analyzed at the Adirondack Ecological Center Laboratory for reaction (pH) and specific conductance. Supporting weather information will be collected daily. All information will be transmitted to the NADP Central Analytic Laboratory (CAL) for further analyses including chemical constituent characterization.

Progress: 83/10 to 84/09. Atmospheric deposition was measured at Huntington Wildlife Forest in the central Adirondack Mountains in cooperation with the National Atmospheric

Deposition Program during 1978-1983. Volume-weighted mean pH was 4.18 compared with the NADP lab measured value of 4.34. Annual wet deposition of sulfate measures 23 kg ha while nitrate deposition measures about 14 kg ha. Major mechanisms for input of ions to hardwood and conifer forests at Huntington Forest were studied. Transport of ions from atmosphere to forest floor were identified using regression analyses and the assumption that deciduous and coniferous forests capture particulate matter and aerosols with differing efficiencies. Impaction of suspended particulates and aerosols was an important source of sulfate and nitrate and these ions may contribute to leaching of calcium from foliage.

Publications: 83/10 to 84/09
MOLLITOR, A.V. and RAYNAL, D.J. 1983.
Atmospheric deposition and ionic input in Adirondack Forests. Journal of the Air Pollution Control Association 33: 1032-1036.

02.047* CRIS0080035
IMPACTS OF FOREST LAND USE ON WATER QUALITY IN NORTH CAROLINA

GREGORY J D; Forestry; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
Proj. No.: NC03691 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 85

Objectives: Develop a physiographic system of classifying forest habitat regions in North Carolina that will be applicable to both site quality and hydrologic characteristics, conduct a problem analysis of specific data needs for natural water quality and for pollution resulting from silvicultural activities, and implement priority field studies identified in the analysis.

Approach: Tentative forest habitat regions have been delineated on imagery and will be further refined by incorporating geologic, soils, hydrologic, and climatic data. Regions will be ranked according to potential for water pollution related to forestry activities and prioritized for further study. An extensive problem analysis will be utilized to define and prioritize research needs in the area of forestry and water quality. Field studies will be designed and implemented to address the highest priority questions identified.

Progress: 84/01 to 84/12. This project was extended to September 1985 to allow completion of a study of the relationship of turbidity to suspended sediment concentration in small Piedmont streams. Grab samples have been collected during the year and preliminary regressions have failed to show a strong correlation between sediment concentration and turbidity. A runoff measurement station has been installed with a stage actuated water sampler in order to collect a number of samples across each stormflow hydrograph. Planning is underway for a new project on forest water management in the lower Coastal Plain. Preliminary field work has been initiated for

two studies in cooperation with the International Paper Company and the North Carolina Forest Service. The first experiment will determine the influence of drainage ditch spacing and water control on water table behavior and tree growth. The second study is a long-term paired watershed experiment to determine the hydrologic impacts of drainage. GRADUATE STUDENTS = 2.

Publications: 84/01 to 84/12

- BLANK, G. B., DILLON, P. J. and GREGORY, J. D. 1984. Hydrology. pp. 427-433. In: The Acidic Deposition Phenomenon and Its Effects: Vol. II. Effects Sciences. Critical Assessment Review Papers. USEPA.
- GREGORY, J. D. 1984. Forestry-processing and field water management. Sec. IIC. pp. 39-46. In: Assessment of available water resources, water issues and future demands. Report of the Water Conservation and Utilization Task Force.
- GREGORY, J. D. 1984. Water management for silviculture in the lower Coastal Plain. Paper presented to Annual Conference of the National Council on Air and Stream Improvement for the Pulp and Paper Industry. Atlanta, GA, May 30, 1984.
- GREGORY, J. D. 1984. Availability and demands for water in forestry. N.C. Chapter, SCSA, Annual Meeting. June 15- 16, 1984. Raleigh, NC.

02.048* CRIS0093520 THE ECONOMICS OF RESIDUALS: SOIL EROSION AND SEDIMENT; SLUDGE AND SOLID WASTE; ACID RAIN

FORSTER D L; SOUTHGATE D JR; HITZHUSEN F J;
Agri Economics & Rural Sociol; Ohio State
University, Columbus, OHIO 43210.
Proj. No.: OH000780 Project Type: HATCH
Agency ID: CSRS Period: 01 AUG 84 to 31 OCT 87

Objectives: Explore the economics of technically viable options for controlling soil erosion and sediment deposition in the East Fork of the Little Miami River Basin (Southwestern Ohio) and the Valdesia Watershed (Dominican Republic), recycling sludge, metals and other valuable residuals, and reducing both source emissions and receptor damage from acid rain.

Approach: The analysis of soil erosion and sediment control requires estimates of costs and benefits for three groups - farmers, downstream water users, and future generations of producers. Also, options for controlling erosion may impact regional economics, and these will be investigated through regional input-output models. Analysis of recycling sludge and other residuals requires estimates of benefits and costs. The focus will be economies of size in composting plants and the effect of composting on wastewater treatment costs. Cost effectiveness estimates will be made for options to control acid rain. Also, institutional mechanisms for dealing with the spillover aspects of acid rain will be inventoried.

Progress: 84/08 to 84/12. D. Southgate was one of two principal investigators on a study of the feasibility of using heat generated at the Piketon, Ohio uranium enrichment facility to heat a greenhouse complex. Five faculty members and three graduate students participated in the study, which was funded by DOE. In addition to the final report, manuscripts based on project research have been submitted to J. Am. Soc. Hort. Sci. and J. Northeastern Ag. Econ. Council. Articles describing research on third world soil erosion problems written by Doug Southgate, Fred Hitzhusen, and others have appeared or will shortly appear in Am. J. Ag. Econ., Land Econ., and Water International. Papers on the same topic were presented at the East-West Center and at annual meetings of the Am. Ag. Econ. Assoc., and the Soil Conservation Society of America. Forster's work in the area of soil erosion and sediment has resulted in two manuscripts being accepted for publication. One reported the results of six years of work in the Lake Erie Basin. It describes a program to reduce pollutant loads to Lake Erie. The other manuscript reports estimates of off-farm costs of oil erosion in northwestern Ohio.

Publications: 84/08 to 84/12

- FORSTER, D.L. and ABRAHAM, G. 1985. "Sediment deposits in drainage ditches: a cropland externality," Journal of Soil and Water Conservation.
- FORSTER, D.L., LOGAN, T.J., YAKSICH, S.M. and ADAMS, J.R. 1985. An accelerated implementation program for reducing diffuse source phosphorus load to Lake Erie. Journal of Soil and Water Conservation.

02.049 CRIS0084308 ACUTE AND CHRONIC EFFECTS ON FISH EXPOSED CONTINUOUSLY AND INTERMITTENTLY TO TOXICANTS

CURTIS L R; WARREN C E; SEIM W K; Fisheries & Wildlife; Oregon State University, Corvallis, OREGON 97331.
Proj. No.: ORE00910 Project Type: STATE
Agency ID: SAES Period: 01 JUL 81 to 30 JUN 86

Objectives: The potential for environmental contaminants to produce adverse effects on natural populations is not easily extrapolated from laboratory data. Expanded knowledge of how temporal factors contribute to tolerance of fishes to toxic substances is necessary for development of environmental policy. The influence of manipulation of schedules of toxicant exposure on salmonid survival, growth and development will be studied.

Approach: The toxicity of copper and an additional agent to salmonids following continuous and intermittent exposure will be assessed. Juvenile rainbow trout will be utilized for determination of LC50 values, the results being coupled with 21 day growth studies. Embryo-larval tests will be conducted to ascertain the responses of another stage in the life history of rainbow trout to variation in exposure regimens of toxic substances. Tissue residue analysis will be utilized to gain insight into how dispositional factors may

influence differential toxicity attributable to temporal aspects of exposure.

Progress: 83/01 to 83/12. Effects of cyclic exposures to environmental acidity on growth and survival of embryonic and larval brook trout (*Salvelinus fontinalis*) were studied. Exposure regimens were designed to model durations and frequencies of pH changes found in natural waters impacted upon by acidic precipitation. Experiments were conducted in a flow-through system in which water chemistry was rigidly controlled to maintain solute content within a range comparable with dilute surface waters where environmental acidification has occurred. Both short- and long-duration acidic conditions were tested to simulate acid rain and snow melt events, respectively. Five pH's between 4.0 and 6.8 were studied. Short-duration events (4.5 hr/day, 1 day/wk, 1 day in 4, 4 days in 8) occurred as repetitive cycles throughout the 70-day experiment. Long-duration events (2 wk) occurred once or twice over the course of the study at different life stages of the developing fish. In order to permit direct comparison between treatment regimen exposures were expressed as mean hydrogen ion concentration (H⁺) which animals experienced over the entire study. Results were compared to continue exposures at constant concentrations. For short and long-duration regimens more toxicity was attributable to intermittent than continuous exposures at equivalent (H⁺), except 4.5 hr/day.

Publications: 83/01 to 83/12

- SHUBAT, P.J. and CURTIS, L.R. 1983. Influence of route of exposure on toxicity and accumulation of dieldrin in trout. Proc. West. Pharmacol. Soc. (ABSTRACT). Submitted.
- SIDDENS, L.K., SEIM, W.K., CURTIS, L.R. and CHAPMAN, G.A. 1983. Toxicity of environmental acidity on various life stages of brook trout. Proc. West. Pharmacol. Soc. (ABSTRACT). Submitted.
- SEIM, W.K., CURTIS, L.R., SIDDENS, L.K. and CHAPMAN, G.A. 1983. Effect of varied exposure duration or toxicity of environmental acidity to developing salmonid embryos. Proc. West. Pharmacol. Soc. (ABSTRACT) Submitted.
- CURTIS, L.R., SEIM, W.K. and CHAPMAN, G.A. 1983. Growth and survival of developing steelhead trout continuously or intermittently exposed to fenvalerate. Aquatic Toxicol. Submitted.

02.050* CRIS0090257
RELEASE OF ALUMINUM FROM SOILS BY ACID
PRECIPITATION

HODGES S C; Agronomy & Soils; Clemson University, Clemson, SOUTH CAROLINA 29631.
 Proj. No.: SC01050 Project Type: STATE
 Agency ID: SAES Period: 01 JUL 83 to 31 AUG 85

Objectives: To ascertain the relationship of aluminum mobilization by acid precipitation with soil physiochemical factors such as pH, cation exchange capacity organic matter content

and clay mineralogy. To define and verify the pathways involved in the release of Al by soils subjected to environmentally relevant concentrations of acid inputs. To identify the species and complexes of Al released by soils to percolating waters. To validate and refine existing chemical simulation models for predicting nutrient loss and aluminum mobilization from soils as a result of acid precipitation.

Approach: Sequential batch extractions and column studies will be used to examine the effects of two synthetic acid rain solutions (pH 4.0 and 3.0) on fully characterized soil horizons dominated by either organic matter, kaolinite-sesquioxides, montmorillonite, vermiculite or gibbsite. Solutions and soils (subsamples) will be analyzed for chemical and mineralogical changes relevant to the stated objectives.

Progress: 84/01 to 84/12. Using synthetic acid rain treatments of pH 4.0 and 3.0, we have found major differences in the processes leading to aluminum release for different soils of the Southeast. At pH 4.0, base exchange initially dominated the buffering reactions in soil, and very little aluminum is released from mineral soil horizons. After 15 sequential treatments, aluminum levels were slowly increasing in the mineral soils. Soil horizons with high organic matter contents released aluminum readily at either treatment pH. At the pH 3.0 treatment level, reacted protons exceeded the exchange capacity of the mineral soils within three treatments, at which point aluminum released exceeded protons reacted, indicating breakdown of clay minerals. Organic matter seemed to offer little additional buffering at this pH level, since very similar amounts of aluminum were released in both treatments for the first two extractions. The aluminum released after these extractions was, as in the mineral soils, much more dependent on the clay mineral content. In conclusion, organically bound aluminum seems to be released more readily than mineral forms, but as acidification proceeds, the bulk of the aluminum will come from mineral sources. Unmanaged soils of the Southeast have very low exchange capacities, and generally have very low base saturations. Ion exchange alone (without base tight cycling) will have little lasting effect in the buffering of these soils against long term inputs of acid.

Publications: 84/01 to 84/12

- HODGES, S.C. and FRANTZ, W.C. 1984. Determination of "active" aluminum A comparative study. Agron. Abstr. 1984, p. 28.
- HODGES, S.C. and JOHNSON, G. 1984. Kinetics of sulfate adsorption and desorption by a Cecil soil using miscible displacement. Agron. Abstr. 1984, p. 178.
- QUISENBERRY, V.L., HATFIELD, M.W. and HODGES, S.C. 1984. Solution and surface diffusion of sulfate in a forested Cecil soil. Agron. Abstr. 1984, p. 180.

02.051 CRIS0084378
CHANGES IN WATER QUALITY ASSOCIATED WITH
LOWLAND FOREST SITE CONVERSION

WILLIAMS T M; ASKEW G R; Forestry; Clemson University, Clemson, **SOUTH CAROLINA** 29631.
 Proj. No.: SCZ00526-FR Project Type: STATE
 Agency ID: OCI Period: 30 SEP 80 to 01 OCT 83

Objectives: Evaluate changes in water quality on wet sites which have received combinations of logging, logging and site preparation, and pine plantation establishment.

Approach: Kilsock Bay, a Carolina bay owned by International Paper Company, has already been divided into subwatersheds by draining and ditching. Stand conditions which will be monitored are natural hardwoods, active logging, completed logging, site prepared areas, young pine plantations and older pine plantations. One storm flow sequence will be collected at 20 points once per month. The following variables will be measured; Temperature, dissolved O(2), pH, flow, dissolved PO(4), NO₃ N, suspended sediment, total P and N in water and sediment and Ca, K, and Mg using standard analytical methods.

Progress: 84/01 to 84/12. A second phase study was begun to ascertain the source of elevated sulfate concentrations in several subwatersheds. Sulfate input and acid precipitation appears to be associated with stagnant high pressure rather than easterly winds. This, along with sulfate to chloride ratio, indicates sea salt aerosols are not the source of sulfate. Aerosol impaction on tree crowns increases sulfate concentration in throughfall by 50% and in stemflow by 100%.

Publications: 84/01 to 84/12

ASKEW, G.R. and WILLIAMS, T.M. 1984. Sediment concentrations of intensively prepared wetland sites. *So. J. App. For.* 8(3):152-157.

WILLIAMS, T.M. and ASKEW, G.R. 1985. Water Quality Changes Associated with Forest Drainage and Pine Plantation. Establishment in Proceedings. Third Southern Silvicultural Symposium. (In press).

fertilizer requirements of blueberries and peaches under East Texas conditions. Determine the effect of acid rain on East Texas soils and crops. Relate crop responses from various plant nutrient applications to the soil test level of those nutrients in order to improve the predictability of the soil test for fertilizer needs.

Approach: Field studies on bench mark soils of East Texas will be used to evaluate the responses of soils and crops to fertilizer nutrients and limestone. Greenhouse research will support the field studies. Soil and plant analyses in the laboratory will help evaluate field and greenhouse experiment responses. Data will be evaluated by appropriate statistical analyses.

Progress: 84/01 to 84/12. Ryegrass yield responses to limestone rates of 0, 672, and 3810 kg/ha were 3119, 5063, and 6020 kg/ha, respectively. Yields increased from 4120 to 5629 kg/ha as P rate increased from 0 to 240 kg/ha, respectively. Winter wheat grain yield increased from 1463 to 4016 kg/ha with N rate increments from 0 to 224 kg/ha, respectively, but yield differences due to the N sources ammonium nitrate, urea, and urea phosphate were negligible. Prior year growth of subterranean clover contributed the equivalent of 70 kg N/ha to the wheat. Winter wheat grain yields were similar for KC1 and K(2)SO(4) potassium sources. Yield response to K rate increases was not statistically significant. A versatile, three-point hitch, tractor-mounted applicator was designed and constructed to dispense fluid fertilizers from containers pressurized by a tractor-mounted and powered pressure system. This applicator is used to evaluate dribble band spacings, methods of application, rates, and combinations of fluid fertilizers applied to Coastal bermudagrass. A severe summer drought restricted growth but grass yield from the three harvests was significantly increased from 11,500 to 15,928 kg/ha as N rate increased from 45 to 135 kg/ha at site one, and from 8064 to 10,080 at site two which is a less responsive soil. Banded urea-ammonium nitrate at spacings of 18, 36, 53, and 71 cm between bands, and method of application had no significant effect on grass yield. Nitrogen source comparisons yielded mixed results between both sites.

Publications: 84/01 to 84/12

NELSON, L.R., HABY, V.A., BATEMAN, C. and KREJSA B. 1984. Accumulation of Al, Ca, Mg, Mn, K and P in annual ryegrass due to soil flooding. *American Society of Agronomy Abstracts*.

BRANDT, J.E., HONS, F.M. and HABY, V.A. 1984. The effect of nitrogen management on the yield and nitrogen uptake efficiency of soft red winter wheat. *American Society of Agronomy abstracts*.

HABY, V.A., DAVIS, J.V. and SMITH, K.L. 1984. A versatile fluid fertilizer applicator for field research. *American Society of Agronomy Abstracts*.

02.052* CRIS0076369
SOIL FERTILITY, MANAGEMENT, AND PLANT NUTRITION
FOR FORAGE AND HORTICULTURAL CROP PRODUCTION IN
EAST TEXAS

HABY V A; Research & Extension Center; Texas A&M University, Overton, **TEXAS** 75684.
 Proj. No.: TEX06320 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 83 to 30 JUN 88

Objectives: Determine the influence of varying levels of soil acidity on the availability of soil and applied fertilizer nutrients for roses and warm and cool season grasses and legumes. Evaluate the efficiency of applied N and that fixed by leguminous plants for small grains and warm season grass production. Evaluate the influence of K fertilizers on disease reduction in small grains and Coastal bermudagrass. Determine the soil fertility and

02.053* CRIS0044490
**SOIL AND WATER MANAGEMENT SYSTEMS FOR
 RECLAMATION OF DISTURBED LAND IN APPALACHIA**

BENNETT O L; BOYER D G; JONES J N; USDA
 Agricultural Research Service, Beckley, WEST
 VIRGINIA 25801.

Proj. No.: 1932-20770-002-00D

Project Type: INHOUSE

Agency ID: ARS Period: 12 MAY 78 to 30 SEP 83

Objectives: Develop reclamation and management practices for strip mines and other disturbedlands to optimize desirable plant growth under stress environments and minimize environmental damage, especially to the hydrology and water quality of the area.

Approach: Work will involve laboratory, growth chamber, greenhouse, and field studies to evaluate chemical, physical, and environmental factors that limit stabilization and reclamation of disturbed land areas. Specific investigative parameters will include hydrologic factors, water quality, plant growth and composition, microbiological populations and changes with treatments, fertilization and liming comparisons, use of domestic and industrial waste materials to reduce acidity and improve soil condition, and ways to avoid toxic trace elements in such wastes.

Progress: 83/01 to 83/12. Performance of yearling steers grazing forages grown on reclaimed strip mined land and treated with fluidized bed combustion residue (FBCR) produced gains equal to those from animals grazing on surface mine land treated with agricultural limestone. The FBCR is a granular material resulting from burning coal in a combustion chamber along with finely ground limestone to reduce sulfur and nitrous oxide emissions which are major sources of acid rain. Data indicates that FBCR can be substituted from limestone for correcting subsoil acidity without having any detrimental effect on the grazing animal. Agricultural use of this material may provide a convenient way of disposing of the waste and providing needed plant nutrient sources for agriculture. In other studies, the effects of revegetation and management practices on water quality on reclaimed surfacemined lands are being studied. The effects of grazing and fertilization programs on effluent quality from reclaimed mine lands will improve our understanding of post mining land use and eliminate water quality problems. The topographic and microclimatic effects on the soil moisture balance of a Central Appalachian surface coal mine indicates that moisture relations can vary widely in mountainous terrain due to slope, exposure, and elevation.

Publications: 83/01 to 83/12

MENSER, H.A., WINANT, W.M., and BENNETT, O.L.
 1983. Spray irrigation with landfill leachate. Biocycle, May-June 1983, pp. 22-25.

GHAZI, H.E., SINGH, R.N., KEEFER, R.F., and BENNETT, O.L. A comparison of level methods for extracting available P from mine soils treated with fly ash and rock phosphate. Presented at NE Branch Am. Soc. of Agron.

Mtg.

BOYER, D.G. 1983. Relation of Surface Runoff Quality to Precipitation Quality on a Surface Coal Mine. Proceedings, National Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation, Lexington, KY. Nov. 29-Dec. 2, 1983.

KEEFER, R.F., SINGH, R.N., BENNETT, O.L., and HORVATH, D.J. 1983. Chemical composition of plants and soils from revegetated mine spoils. Presented at Symposium on Surface Mining, hydrology, Sedimentology, and Reclamation.

02.054* CRIS0044482
**SOIL AND WATER MANAGEMENT SYSTEMS FOR EFFICIENT
 CROP PRODUCTION IN APPALACHIA**

BENNETT O L; LEGG T D; PERRY H D; USDA
 Agricultural Research Service, Beckley, WEST
 VIRGINIA 25801.

Proj. No.: 1932-20780-001-00D

Project Type: INHOUSE

Agency ID: ARS Period: 12 MAY 78 to 20 JUN 83

Objectives: Develop soil, water, and plant management systems for forage, row and specialty crops on the diverse soil resource of the Appalachian region.

Approach: Laboratory, greenhouse, growth chamber, and field studies will be integrated to evaluate fertilizer amendments, use of domestic and industrial waste materials, biological nitrogen fixation, no-tillage production management systems and species for efficient use of naturally occurring plant nutrients for crop production and plant quality.

Progress: 81/05 to 83/05. Subsoil acidity can be corrected by application of large amounts of organic matter containing excessive amounts of calcium and magnesium. Organic matter proved to be an effective source of ligands for chelation and movement of calcium and magnesium into acid subsoils for replacement of high soil aluminum. Sulfur treatments can have a marked effect on efficiency of mineral utilization and protein synthesis in the plant metabolism system. Several studies have demonstrated that conservation tillage can increase yields, water use, and fertilizer use efficiency. Corn can be grown using no-tillage systems where sod regrowth is controlled by use of herbicides. Brome, orchard, and fescue grasses proved to be satisfactory for use with the "sleeping" sod no-till technique. Studies with N15 have shown a higher rate of soil nitrogen mineralization under no-till cropping systems than for conventional tillage. Composition of no-till corn plants indicate a higher concentration of P, K, Mn, Zn, and a lower concentration of Fe, Al, Mg, and N than in the conventionally tilled corn plants. Soil moisture under no-tillage was always higher than for tilled areas. No-till production techniques were demonstrated for potatoes, tomatoes, sweet corn, string beans, and for interseeding various legumes for reclamation of pasture areas.

Publications: 81/05 to 83/05

- HERN, J.L. 1978. Elemental analysis in agriculture using inductively coupled plasma-atomic emission spectroscopy. Fifth Ann. Mtg. Federation Anal. Chem. and Spec. Soc.
- HERN, J.L. and STROHL, J.H. 1978 Modified graphites for chelation and ion exchange. Anal. Chem. 50:1954.
- BENNETT, O.L., STOUT, W.L., HERN, J.L. and SIDLE, R.C. 1978. Potential agricultural uses of fluidized bed combustion waste. Proc. 5th Nat. Conf. on Energy and the environment.
- HERN, J.L., STOUT, W.L., SIDLE, R.C. and BENNETT, O.L. 1978. Characterization of fluidized bed combustion waste: Composition and variability as they relate to disposal on agricultural lands.
- BENNETT, O.L., REID, R.L., WHITSEL, T.J., MITCHELL, D.M., STOUT, W.L., HERN, J.L. and MAY, D.L. 1982. Animal feeding trials using feed and food produced with FBCR. Proc. of 7th Intl. Conf. on FBC. Vol. 1. pp. 559-566.

02.055 CRIS0000005
ENVIRONMENTAL HYDROLOGY OF THE CALIFORNIA SNOW ZONE

BERG N; MCGURK B; Pacific Southwest Forest and Range Experiment Station; Medical College of Wisconsin, Milwaukee, **WISCONSIN** 53226.
 Proj. No.: PSW-1601 Project Type: INHOUSE
 Agency ID: FS Period: 20 JUN 84 to 20 JUN 89

Objectives: To determine hydrologic principles of snow accumulation and melt, develop guidelines for their use in multiple-use management of the forests of the snow zone of California, and evaluate the role of atmospheric deposition on snowpack chemistry in the Sierra Nevada.

Approach: Physical process models will be developed to improve the estimation of runoff timing and volumes from Sierra Nevada lands where snow melt is a significant water source. The extent of acid deposition in mountainous areas of California will be evaluated through collection and analysis of field data on snow, and soil and surface waters.

Progress: 83/10 to 84/09. The snowpacks of the Sierra Nevada provide a major portion of all water reaching California's streams. Hydroelectric power production, irrigated agriculture and domestic water supply are three major uses of water from the California snow zone. Power company estimates of the equivalent fuel cost attributable to water from the snow zone of the west slope of the Sierra Nevada is in the \$700 to \$900 million range, with a "good" snow year equating to a \$100 million saving in alternate fuel costs. The Research Work Unit is developing improved methods of streamflow estimation, particularly during situations such as rainfall onto the snowpack, that are imperfectly handled by current methodologies. In addition, potential water quality damages resulting from atmospheric deposition are being investigated. Systems for

distinguishing between precipitation types have been assessed and a prototype instrument based on a laser technology has been developed. A system for monitoring snowpack liquid water amounts and based upon electrical capacitance is being developed and will be evaluated during fiscal year 1985. Two models estimating snowpack water equivalence, one based upon historical data and second on snowpack processes, have been developed. These procedures estimate water equivalence over a major basin on the Sierra Nevada's west slope.

Publications: 83/10 to 84/09

- BERG, N.H. and HANNAFORD, M.A. 1983. Application of a snowpack water equivalent model to rain-on-snow events in the central Sierra Nevada. Proc. West. Snow Conf., p. 155-158.
- BERG, N.H., BENEDICT, N. and HARRIS, E. 1984. Environmental aspects of weather modification for snowpack enhancement. Proc. East. Snow Conf., p. 13-23.
- BERG, N.H. and BERGMAN, J.A. 1984. Roadway salting effects on snowmelt water quality. Proc. Specialty Conf., Irrig. and Drain. Div., Amer. Soc. Civ. Eng.: Water--Today and Tomorrow, p. 237-246.
- BERGMAN, J.A. 1983. Hydrologic response of central Sierra Nevada snowpacks to rainfall. Proc. West. Snow Conf., p. 141-144.
- KATTELMANN, R.C., MCGURK, B.J., BERG, N.H., BERGMAN, J.A., BALDWIN, J.A. and HANNAFORD, M.A. 1983. The isotope profiling snow gage: twenty years of experience. Proc. West. Snow Conf. p. 1-8.

02.056* CRIS0077498
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

BOCKHEIM J G; Soil Science; University of Wisconsin, Madison, **WISCONSIN** 53706.
 Proj. No.: WIS02372 Project Type: HATCH
 Agency ID: CSRS Period: 10 OCT 77 to 30 SEP 83

Objectives: Determine spatial and temporal trends in supply of beneficial and injurious substances in precipitation and dry particulate matter deposited in various regions of the U.S.

Approach: Samples of precipitation and dry particulate matter will be collected weekly at one site in Wisconsin and analyzed for SO(4), NO(3), PO(4), DI, NH(4), Na, Ca, Mg, pH, total and free acidity, and electrical conductivity.

Progress: 83/01 to 83/12. The principal objective of this research is to collect and analyze samples of precipitation to monitor the spatial and temporal trends of beneficial and injurious substances in precipitation deposited in various regions of the United States. The Wisconsin Department of Natural Resources has established collection sites at Rhinelander, WI and Spooner, WI. All the samples are being analyzed and the data processed at the central laboratory in Urbana, IL. Data are available from the National Atmospheric Deposition Program, Fort Collins, CO, 80523. The College of Agricultural and Life Sciences at the

CM 02

University of Wisconsin-Madison is not presently doing research on this project. It serves as a coordinator between the state agencies and the National Monitoring Network

Publications: 83/01 to 83/12

NO PUBLICATIONS REPORTED THIS PERIOD.

CM 03 WATERSHEDS AND RIVER BASINS

03.001* CRIS0089881
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS AND
MATERIALS**

BURGY R H; CARROLL J J; FLOCCINI R G; Land,
Air & Water Resources; University of
California, Davis, **CALIFORNIA** 95616.
Proj. No.: CA-D*-LAW-4311-RRProject Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize
biologically important geographical and
temporal trends in the chemical climate of
North America.

Approach: Studies will be conducted to identify
and improve efficiency for collection of
naturally- and anthropically-generated gaseous
and particulate components added to,
distributed by and deposited from the
atmosphere which may have beneficial or
injurious impact on components of terrestrial
and aquatic ecosystems. Major sources and
composition of atmospheric pollutants and
atmospheric processes involved in their
distribution and deposition will be
investigated.

Progress: 84/01 to 84/12. During 1984, the
Davis site operated on a continuous basis to
monitor precipitation deposition. This portion
of the project is attempting to identify acidic
deposition products contained in rain samples
and to define the sources of acidic
constituents that contribute to acidity of
rainfall here. The program was modified on July
1, 1984 to discontinue collections of dry
deposition samples (only a few stations in the
U.S. will take dry samples hereafter). The
Davis site was inspected by NADP this year and
minor adjustments in equipment were made to
conform to network specifications. A total of
20 rain samples were collected in the year,
these yielding pH values ranging from 5.0 to
6.5. The average of all samples is about 5.8 pH
units, indicating a nearly neutral acidity in
Davis rainfall. Spring rains tend to have
higher pH values (about 6.0) and Fall rains
tend to be lower (5.0 to 5.5), suggesting some
effect due to strong inflow in early winter
storms that generally translate into the upper
delta area (Davis) from the southwest and
include trajectories passing over the
metropolitan bay-delta region. The limited
numbers of events sampled makes all
interpretations inconclusive, and will require
longer experience to resolve.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

03.002* CRIS0089880
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS**

WHITTIG L D; BURAU R G; HUNTINGTON G L; Land,
Air & Water Resources; University of
California, Davis, **CALIFORNIA** 95616.
Proj. No.: CA-D*-LAW-4312-RRProject Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of
atmospheric deposition on the following: the
productivity of agricultural crops, forest
trees, rangelands, wetlands, and soils; the
health and productivity of domestic food
animals, wildlife and fish; the chemical
composition of surface and ground waters; and
atmospheric visibility and the corrosion of
metals, masonry and stone, paints and other
protective coatings, and other materials in
machinery or structure.

Approach: Studies will evaluate sensitivity of
soils, waters, and terrestrial and aquatic
organisms to atmospheric deposition, chemical
and biological processes in soils, waters and
organisms affected by atmospheric deposition,
and terrestrial processes and agricultural and
forest practices as may influence effects of
deposition on aquatic systems.

Progress: 84/01 to 84/12. Investigations
under this project contribute to an integrated
long-term study of potential impacts of
atmospheric deposition on terrestrial and
aquatic ecosystems of the Sierra Nevada.
Centered in Sequoia National park, this project
focuses on buffering characteristics of soils
of the program study area, on release of
chemical elements from the soils in response to
acidity and alkalinity inputs, on mechanisms
involved in dissolution and transport of
mineral elements and on the input-output
balance for sulfuric acid added to the soil
systems. A total of 26 surface profile samples
from representative soils have been subjected
to a buffer performance test involving graded
additions of H_2SO_4 and $Ca(OH)_2$. The pH of
the systems was measured weekly for 6 weeks to
observe the time course of buffering for each
profile sample. Aqueous extracts from treated
samples have been analyzed for major cations
and anions. The pH data have been transformed
into van Slyke buffering index curves and
apparent sulfate adsorption has been
calculated. The mineralogy has been
qualitatively determined for silt and clay
fractions of 12 of the surface profile samples.
Buffering and sulfate adsorption have been
unexpectedly strong in many samples while
element release has been unexpectedly small. In
addition to a wide diversity of phyllosilicate
minerals in different soils of the area, there
is a relatively high proportion of glass in a
number of surface samples, suggesting a
volcanic ash deposition source.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

03.003* CRIS0062810
**UTILIZATION, CONVERSION, AND MANAGEMENT OF
SOUTHERN CALIFORNIA BRUSHLAND**

YOUNGNER V B; NUDGE F J; Botany & Plant
Sciences; University of California, Riverside,
CALIFORNIA 92521.
Proj. No.: CA-R*-BPS-2861-H Project Type: HATCH
Agency ID: CSRS Period: 03 OCT 72 to 31 MAR 84

Objectives: Develop a basis for brushland utilization and management through studies on potential uses of bursh species, effects of harvesting methods, substitution of exotic species, seedling establishment, competition among native and exotic species, physiology of resprouting.

Approach: Through field, greenhouse, growth chamber, and laboratory studies. Field studies will be in natural brushlands and field plantings, using portable research equipment. Laboratory analyses to plant tissue constituents and soil properties will be correlated with field observations. Specific environmental responses will be studied in greenhouse and growth chambers.

Progress: 84/01 to 84/03. Investigations of annual range plant responses to the air pollutants O₃ and SO₂ were conducted in fumigation chambers. In *Bromus rubens* ozone both reduced yield and affected several aspects of quality. Sulfur dioxide effects were less and primarily involved quality factors. Interaction of the two pollutants was not shown. Chronic SO₂ exposure of *Bromus mollis* and *Erodium botrys* also resulted in yield reductions with carbohydrate allocation to the root zone being significantly reduced in *B. mollis*. *Erodium* growth showed some stimulation at the low SO₂ level but not at higher levels. Shoot sulfur content in *Bromus* was higher than in *Erodium* at comparable fumigation levels. Detrimental effects of fumigation were often not immediately apparent but developed as the season progressed. These studies indicated that air pollutants affect growth of brushland plants and may change species composition in affected areas. In some regions of high pollutant levels, value of the vegetation for forage and erosion control may be impaired and type conversion to species shown to be more tolerant may be desirable. Preparation of data for formal publication has continued.

Publications: 84/01 to 84/03

NO PUBLICATIONS REPORTED THIS PERIOD.

03.004 CRIS0100000
THE ECOLOGY OF CHAPARRAL AND ASSOCIATED ECOSYSTEMS

CONRAD S; DUNN P; MILLER P; Pacific Southwest Forest and Range Experiment Station; USDA Forest Service, Riverside, CALIFORNIA 92507.
Proj. No.: PSW-1653 Project Type: INHOUSE
Agency ID: FS Period: 02 MAY 84 to 02 MAY 89

Objectives: To advance the understanding of the processes that determine nutrient status, erosion potential, water yield, plant community development, productivity, and reproductive success in chaparral and associated ecosystems. Relate these processes to various land treatments, especially fire, and provide guidance to managers to help meet resource objectives.

Approach: Approach: To achieve better understanding of major ecosystem processes and to relate these processes to solving resource

management missions, this Research Work Unit will utilize multidiscipline research techniques involving erosion hydrology, soil and plant. Sciences concerned with nutrient budgets, the relative microbiological sciences, physiological ecology, fire effects research, plant community development ecology, and air pollution research.

Progress: 83/10 to 84/09. RWU scientists have participated in the National Research Council analysis of landslides and flood disasters along Utah's Wasatch front. They have also developed (with the Geological Survey) a method to create soil slips on demand for research purposes. The National Atmospheric Deposition Program sampler on the San Dimas Experimental Forest gave some of the highest rates of nitrogen and sulfur deposition in the nation. A study of denitrification by nitrifiers was completed and a study of stream bed denitrification of smog-deposited nitrogen was started. Work was begun on the effects of dry deposition nutrients on leaf surface epiphytic microbes. Work was started on mixed ozone and sulfate smog on seedlings of sequoia and black oak. Tree ring analysis for historical effects of smog on tree growth was started in conjunction with the National Park Service. Thinning studies to ameliorate smog effects on oaks were accomplished. Preparations were made for a watershed-level study of smog nitrogen storage in chaparral soils and its release as the result of fire.

Publications: 83/10 to 84/09

- ANDERSON, L.R.; KEATON, J.E.; SAARINEN, T.; WELLS, W.G. The Utah landslides, debris flows, and floods of May and June 1983. Report CETS-CND-025. Washington, DC: National Academy Press; 1984. 90 p.
MILLER, P.R. and WINER, A.M. Composition and dominance in Los Angeles basin urban vegetation. *Urban Ecology* 8: 29-54; 1984.
MILLER, P.R. Ozone effects in the San Bernardino National Forest. In: Proceedings of Symposium on Air Pollution and the Productivity of the Forest. October 4-5, 1983; Washington, D.C.: Isaac Walton League of America.
CONARD, S.G. Phenology of shrub species--its relevance to forest vegetation management. In: Proceedings 5th Annual Forest Vegetation Management Conference. Sacramento, CA. Nov. 2-3. 1983. Placerville, CA.
CONARD, S.G.; EMMINGHAM, W.H. Herbicides for shrub control on forest sites in northeastern Oregon and northern Idaho. Special Publication 5. Corvallis, OR: Forest Research Laboratory. College of Forestry. Oregon State University; 1983.

03.005* CRIS0100004
ATMOSPHERIC DEPOSITION IN NATURAL ECOSYSTEMS OF THE WESTERN UNITED STATES

FDX D G; Rocky Mountain Forest and Range Experiment Station; Colorado State University, Fort Collins, COLORADO 80523.
Proj. No.: RM-2153 Project Type: INHOUSE
Agency ID: FS Period: 01 OCT 84 to 30 SEP 89

Objectives: Create the basic knowledge needed to determine aquatic and terrestrial ecosystem effects resulting from specifically identified air pollution sources.

Approach: The research is sequentially structured to provide (1) protocols for quantifying physical and chemical environmental factors that influence aquatic and terrestrial ecosystems, (2) a better understanding of atmospheric delivery and ecosystem reception of air pollutants, and (3) knowledge of the biological effects caused by air pollutants introduced into ecosystems.

03.006 CRIS0083112
LAND USE AND SURFACE WATER QUALITY

FRINK C R; SAWHNEY B L; Soil & Water; Connecticut Agric Expt Sta, New Haven, CONNECTICUT 06504.
Proj. No.: CONH00741 Project Type: HATCH
Agency ID: CSRS Period: 01 JAN 81 to 01 JAN 84

Objectives: Determine the improvement in water quality that can be obtained by limiting known inputs of phosphorus and other pollutants.

Approach: Refine estimates of phosphorus losses from watersheds of 37 additional lakes. Determine internal loading of phosphorus in lakes. Evaluate effectiveness of alum as in-lake restoration technique. Evaluate effectiveness of Best Management Practices in watershed with one third of land in agriculture. Measure transport of sediment, phosphorus and polychlorinated biphenyls to determine in-lake attenuation.

Progress: 83/01 to 83/12. A total of 70 Ct. lakes were analyzed during 1973-1980, and the data have now been summarized. Despite continuing controversy over interpretation of the National Eutrophication Survey, our data clearly show that phosphorus is the element controlling the growth of algae in our lakes and that nitrogen is seldom limiting. The transparency of the lakes is determined largely by the growth of algae and can be predicted from measurements of chlorophyll-a and color. Comparable data for thirty-five lakes obtained in 1937-1939 show that total phosphorus and chlorophyll have increased in most lakes, with a consequent decrease in transparency. The alkalinity of this group of lakes does not appear to have changed. Predictions of phosphorus concentrations in the lakes using a model developed earlier for a subset of thirty-three lakes agreed reasonably well with observed concentrations. This information should aid us in developing strategies to control nutrient enrichment so that future generations can use the land and still enjoy the lakes and ponds of Connecticut

Publications: 83/01 to 83/12

FRINK, C.R. and NORVELL, W.A. 1983. Chemical and physical properties of Connecticut lakes. Conn. Agr. Exp. Sta. Bull. 817 (in press).

03.007* CRIS0085035
DEVELOPING FORESTS: EFFECTS ON SOIL AND WATER QUALITY

KRUG E C; FRINK C R; Soil & Water; Connecticut Agric Expt Sta, New Haven, CONNECTICUT 06504.
Proj. No.: CONH00744 Project Type: HATCH
Agency ID: CSRS Period: 07 AUG 81 to 16 SEP 83

Objectives: Determine changes of five benchmark soils established in 1927 under developing Connecticut forests. Characterize soils from farm fields, developing and mature forests in the Bantam Lake watershed. Determine sediment characteristics and phosphorus in runoff from these soils. Determine ability of sediment to sorb or release phosphorus after deposition in Bantam Lake.

Approach: Determine physical, chemical and mineralogical properties of soils collected from long term forest plots and compare with analyses obtained 1927-1931. Analyze soils across the successional gradient in the Bantam Lake watershed. Measure phosphorus and suspended sediment in low order streams during low and high flow in the watershed. Incubate silt-sized samples from these watershed soils in sediments in Bantam Lake.

Progress: 83/01 to 83/09. Several small lakes in Connecticut have apparently become acidified according to a recent study of lakes in New England by the U.S. Fish and Wildlife Service. The most pronounced acidification was observed in Emmons Pond in Hartland, CT where the pH is now approximately 4.6. Preliminary investigations revealed that the pond was created by damming a former swamp. Most of the watershed was farmed at one time but now supports a mature stand of hemlock. Streams entering the lake pass through and are acidified by sphagnum peat moss. The specific mechanisms responsible for acidification will be examined more thoroughly in the coming year under Hatch 747.

Publications: 83/01 to 83/09

KRUG, E.C. and FRINK, C.R. 1983. Acid rain on acid soil: A New Perspective. Science 221:520-525.
KRUG, E.C. and FRINK, C.R. 1983. Effects of acid rain on soil and water. Conn. Agr. Exp. Sta. Bull 811. In Press.

03.008* CRIS0083303
IDENTIFICATION AND MOVEMENT OF ORGANIC CHEMICALS IN SOILS

SAWHNEY B L; FRINK C R; KOZLOSKI R; Soil & Water; Connecticut Agric Expt Sta, New Haven, CONNECTICUT 06504.
Proj. No.: CONH00742 Project Type: HATCH
Agency ID: CSRS Period: 01 JAN 81 to 29 JUL 85

Objectives: Investigate the reactions and movement of organic chemicals in soils to provide safe disposal of organic pollutants. To improve the purge and trap method for the analysis of volatile organic compounds by GC and GC/MS.

Approach: Measure reaction and movement of organic chemicals in soil columns in the laboratory. Measure organic chemicals in leachates from landfills, industrial disposal sites, and agricultural fields. Develop predictive models for movement of chemicals. Study trap adsorbents, columns, and relative volatility. After volatility with acids, bases, redox and other reagents.

Progress: 85/01 to 85/07. Investigation of the movement of organic pollutants in the groundwater beneath a landfill in Granby, CT have been completed. Diethyl ether, methylethyl ketone, methylisobutyl ketone, benzene and toluene were the major pollutants identified. The plume was found to move from east to west as predicted from the general hydrology of the region. However, a number of borings revealed a north-south trough in the bedrock that bisects the landfill site. During low flow, leachate appeared to be caught in the trough and redirected into southerly flow. Capping the landfill site and diversion of storm water effected rapid decrease in the concentration of pollutants in monitoring wells at the site, but had little influence on bedrock wells to the south. Thus, local hydrologic features may be important in determining the exact pattern of movement of pollutants.

Publications: 85/01 to 85/07

SAWHNEY, B.L. 1985. Vapor-phase sorption and polymerization of phenols by smectite in air and nitrogen. *Clay and Clay Min.* 33(2):123-127.

SAWHNEY, B.L. and KOZLOSKI, R.P. 1985. Reply to "Comments on Organic Pollutants in Leachates from Landfill Sites." *J. Environ. Qual.* 14(1):157.

03.009* CRIS0089958
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

RIEKERK H; GHOLZ H L; CANFIELD D E; Forest Resources & Conservatn; University of Florida, Gainesville, FLORIDA 32611.
 Proj. No.: FLA-FOR-02321 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America, (Network Research), and to assess the effects of atmospheric deposition on land productivity, animal productivity, and water quality (Effects Research).

Approach: Network Research. Wet/dry fall collection stations in Florida in association with weather stations of ongoing research programs directly benefitting from the atmospheric deposition data. Weekly collection and sample shipment with weather data to, and return of data and synthesis reports from NADP central laboratory. Effects Research. Comparative importance of wet/dry fall on nutrient status of plants, soil and waters (Proj. Stat., A4). Effects wet/dry fall on forest nutrient cycling and forest tree growth

(B1, 2). Influence on A1 mobility and toxicity to fine tree roots (B6).

Progress: 83/10 to 84/09. Atmospheric deposition was monitored weekly at the Bradford Forest weather station in north-central Florida from Jan 1978 through Aug 1984. Acidity data from the first five years showed a highly significant drop of 0.2 pH units per year down to pH 4.6. Data from the sixth year initially followed the same trend but a reversal began after the summer of 1983 raising the average pH to about 5.0 during the summer of 1984. Plant nutrient inputs with rainfall during 1983 remained similar to that of the previous year and appeared to be significant for the longterm productivity of the sandy acid-leached pine flatwoods soils.

Publications: 83/10 to 84/09

RIEKERK, H. and KORHNAK, L.V. 1984. Environmental Effects of Silviculture in Pine Flatwoods. In 'Third Biennial Silvicultural Research Conference' Atlanta, GA, November 1984: (In press).

03.010 CRIS0047837
IMPACTS OF AGRICULTURE ON GROUNDWATER RECHARGE WATER QUALITY

BECK B F; ASMUSSEN; Geology & Geophysics; Georgia Southwestern College, Tifton, GEORGIA 31793.

Proj. No.: 7006-20810-006-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 14 JUL 82 to 30 SEP 83

Objectives: Determine conductivity, pH, alkalinity, carbon dioxide, total (Ca, Mg), turbidity, nitrogen and phosphate species, and chloride concentrations in the Tallahatta groundwater aquifer. Relate background information of the recharge area (land-use, geology, topography, and cultural history) to hydrochemical clusters and overall management practices to ascertain the impact of applied agricultural chemicals on groundwater recharge water quality.

Approach: Collect groundwater samples from the Tallahatta formation at selected sites. Samples will be analyzed for selected chemical parameters. Land management records, groundwater tables, rainfall, and geologic records will be obtained and related by cluster analyses to the chemical parameters.

Progress: 82/03 to 83/09. Water samples were collected from 34 wells (March 1982 through March 1983) in the Claiborne aquifer in southwest Georgia. Land use is principally forest, wetland, or agriculture. The aquifer is exposed surficially to the northwest, but dips beneath confining beds to the southeast. The Claiborne aquifer is generally a fine- to medium-grained quartz sand becoming more calcareous down dip and to the east. The well water was analyzed in situ for pH, conductivity, alkalinity, hardness, and temperature. Samples were analyzed in the laboratory for C1, NH(4), NO(3), total N, total P, ortho-P, SO(4), K, Na., Ca., Mg., and Fe.

Natural variations in the water chemistry reflect variations in the aquifer lithology. Hardness gradually increased from 5 ppm. updip to 162 ppm. downdip and to the east. Bicarbonate alkalinity reflects exactly the same trend because the dissolution of CaCO_3 by acidic groundwater yields both calcium and bicarbonate ions. Higher than normal nitrate-nitrogen concentrations (4-6 ppm.) are found in groundwater in the exposed updip portion of the aquifer in areas where agricultural land use is high. However, in forest covered areas, groundwater in the exposed portion of the aquifer contains nitrate concentrations similar to the confined areas of the aquifer: less than 1 ppm. Other agricultural chemicals do not show a discernible variation. Bi-monthly sampling is continuing with additional wells being sampled in the area of higher nitrate concentrations.

Publications: 82/03 to 83/09

BECK, B.F. 1983. Physiographic and geologic controls on agricultural land use in the area of Dawson, Southwest Georgia; (A B.S.), Georgia Journal of Science, Vol. 41, No. 112, pp. 26.

03.011* CRIS0089127
AGGREGATION METHODS FOR ANALYSIS OF COMPLEX PUBLIC PROGRAMS

RANDALL A; HOEHN J P; Agri Economics; University of Kentucky, Lexington, KENTUCKY 40506.

Proj. No.: KY00076 Project Type: HATCH
Agency ID: CSRS Period: 01 DEC 82 to 30 SEP 85

Objectives: To identify the sources of error inherent in customary procedures for aggregating the benefits and costs of complex programs. To complete a theoretical analysis to define correct aggregation procedures. To develop empirical methods which implement, or approximate, correct aggregation procedures.

Approach: Specifications of the benefit aggregation problem, based on line integral concepts, suggest that the conditions under which customary aggregation procedures are correct are very restrictive. This work will continue, to more completely define the problem and to identify necessary and sufficient conditions for correct aggregation. Correct methods for benefit aggregation using contingent valuation methods will be defined. Aggregation of benefits estimated by methods based on market observations will be more difficult. Initial work will focus on competitive and complementary relationships among program components.

Progress: 84/01 to 84/12. In the last year, the research focus has shifted to developing operational methods of approximating the theoretically valid benefit aggregation structure identified in previous research. Initially, two operational structures were identified: a Cobb-Douglas structure that is very restrictive but has low information requirements and a Taylor Series Approximation (TSA) that is flexible but requires much

information. Current research focuses on a Restricted Elasticity Form of the TSA that is a little less flexible but also has less daunting information needs. A "cookbook" for approximately valid piecewise benefit aggregation using the REF has been developed and tested in the context of air and water pollution control programs. Working papers have been prepared. Work on companion projects funded by National Science Foundation and US Environmental Protection Agency is proceeding on schedule. Revision/extension of this project is pending.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

03.012 CRIS0071302
MODELING WATER QUALITY FROM FORESTED WATERSHEDS.

MOORE I D; COLTHARP G B; Agri Engineering; University of Kentucky, Lexington, KENTUCKY 40506.

Proj. No.: KY00132

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 OCT 76 to 30 SEP 86

Objectives: Develop and test hydrologic models for simulating streamflow from forested watersheds. Develop and test models for simulating the quality of water emanating from undisturbed forested watersheds.

Approach: Six forested watersheds are being monitored for water quantity and quality parameters in companion project 603. This data is being made available for use in the proposed project. Hydrologic models will be tested to find one that adequately describes the existing hydrologic response of the watershed. Relationships between selected water quality parameters and streamflow and precipitation will be studied graphically and through mathematical techniques of cross-spectral and cross-correlation analyses. The developed relationships will be used to simulated the water quality emanating from undisturbed forested watersheds of the Appalachian Region. This information will then serve as a base for comparison when various forest practices are imposed on the watershed.

Progress: 84/01 to 84/12. The modeling effort encompassed the development of seasonal flood frequencies on three forested watersheds in Eastern Kentucky. These flood frequency distributions are to be linked with the water quality models in order to determine the potential impact of sediment loads. Specifically flood frequency data is required to determine the frequency, duration, and magnitude of expected sediment and water quality loadings in forested watersheds. Both annual and partial duration flood series were modeled on a seasonal basis. Basin site ranged from 100 to 231 acres. Each basin's data sets for each flood series were successfully fitted by a log-Pearson Type III distribution. Comparisons revealed that the annual period flood frequency curve did not coincide with either seasonal curve for any watershed or with

either flood series. The difference was attributed to the inability of the annual period data to reflect the diverse seasonal nature of the floods. A regional flood frequency curve was constructed for each data set from only the annual series, and provided a more realistic representation of probable flood peak occurrences for the region.

Publications: 84/01 to 84/12

ALBRIGHT, R.C. Flood peak frequencies and magnitudes of three small forested watersheds in Eastern Kentucky. Unpublished Master's Thesis.

03.013* CRISO085425
EFFECTS OF FOREST PRACTICES, SOILS AND PRECIPITATION ON WATER RESOURCES IN MASSACHUSETTS

MADER D L; College of Food & Natural Res.; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00043

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Assess effects of watershed characteristics, forest cover treatments and precipitation on streamflow. Establish criteria for water quality levels in relatively undisturbed watersheds. Develop computer models to predict effects of treatment alternatives on water yield.

Approach: Continuation of research on streamflow initiated under MS-2 using five stream-gauging stations established on Cadwell creek in Cadwell Research Forest. Weekly water samples for complete chemical analysis. The Brook Watershed Model compared with Cadwell computer Model.

Progress: 83/10 to 84/09. Analysis of low density white pine study plots established in 1962 was completed, including volume and basal area growth, and economic analyses. Results demonstrate the soundness of this management option for plantations on watersheds. Low density plots exhibited much larger sizes and quality of stems after 20 years, much earlier merchantability, and very high board foot volumes. Economic analysis indicated substantial benefits in terms of timber values from the treatments, augmenting early gains in reduced transpiration. Stream-flow and water quality monitoring of the Cadwell Creek Watershed were continued in conjunction with the acid deposition (NADP) monitoring program. The data contributes to the national and state acid rain studies. A paper on stream water condition in relation to acid deposition has been submitted for publication. A study of chemical properties of rainfall and throughfall in sugar maple stands on several soils, to examine canopy/rainfall interactions is near completion.

Publications: 83/10 to 84/09

STONE, R. J. 1984. Low density white pine management. M.S. Thesis, University of Mass., Amherst.

03.014* CRISO000153
WATER QUALITY MANAGEMENT IN FORESTS OF THE WESTERN GREAT LAKES REGION

KNIGHTON M D; Forestry Sciences Laboratory; North Central Forest Expt Stat, Grand Rapids, MINNESOTA 55744.
 Proj. No.: NC-1602 Project Type: INHOUSE
 Agency ID: FS Period: 26 NOV 84 to 26 NOV 89

Objectives: To evaluate the impact of acid rain on the soil and water resources of the western Great Lakes region; to evaluate the impact of forest management practices on surface water quality in the western Great Lakes region; and to develop guidelines for environmentally sound uses of natural peatlands for sewage treatment and disposal.

Approach: Acid rain studies will determine the composition of regional precipitation (four NADP-NTN sites); the subsequent effects of vegetation and soil types on soil water and runoff water chemistry (six sites); and final effect on regional lake water chemistry. Forest fertilization and forest harvesting methods and intensities will be assessed for effects on water quality using paired watershed and replicated plots on three soil types. Sewage effluent will be applied to plots in a peatland to determine loading capacity of N and P.

Progress: 83/10 to 84/09. A hummock-hollow level survey of a small Minnesota mire was used to refine the definition of acrotelm and catotelm. The division between these two peat profile layers can be determined more objectively. Regrowth of sphagnum moss on a harvested peatland in east central Minnesota accumulated at 3.9 t/ha/yr. Twenty years of regrowth would return the site to pre-harvest sphagnum biomass. In water impoundments drawdowns do not impair downstream water quality nor do they "rejuvenate" nutrients in the reflooded water. Plant community changes are explained by water level regimes and inherent water quality. Anaerobically digested municipal sludge can be applied to red pine and white pine plantations at 16.5 dry Mg/ha or less and to aspen sprouts at rates up to 19 dry Mg/ha without exceeding 10 mu eq/1 potability standards in groundwater. Addition of wastewater sludges to pine plantations growing on nutrient-poor outwash soils has increased concentrations of N and P in upper soil layers and enhance the short-term growth of understory and overstory vegetation.

Publications: 83/10 to 84/09

VERRY, E.S. 1984. Microtopography and water table fluctuation in a sphagnum mire. In: Proc., 7th International Peat Congress; June 18-23, 1984, Dublin, Ireland. Dublin, Ireland: The Irish National Peat Committee, 2:11-31.

ELLING, A.E. and KNIGHTON, M.D. 1984. Sphagnum moss recovery after harvest in a Minnesota bog. J. Soil and Water Conserv. 39(3):209-210.

VERRY, E.S. 1983. Water quality dynamics in shallow water impoundments of North Central Minnesota. Ph.D. Thesis. Colorado State University, Ft. Collins, CO; 150p.

- BROCKWAY, O.G. and URIE, D.H. 1983. Determining sludge fertilization rates for forests from nitrate-N in leachate and ground water. J. Environ. Qual. 12(4):487-492.
- BROCKWAY D.G. 1983. Forest floor, soil, and vegetation responses to sludge fertilization in red and white pine plantations. Soil Sci. Soc. Am. J. 47:776-784.

03.015* CRIS0088732
**PREDICTIVE MODELS OF WATER QUALITY IMPACTS FROM
 SELECTED ENVIRONMENTAL MANAGEMENT ALTERNATIVES**

PERRY J A; Forest Resources; University of Minnesota, St Paul, MINNESOTA 55108.
 Proj. No.: MIN-42-025
 Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 NOV 82 to 30 SEP 86

Objectives: Develop bivariate and multivariate models relating water quality of small streams to environmental management practices. Test several hydrologic modeling alternatives such as paired watersheds, upstream/downstream stations, stream segment ecosystems, and multiple watersheds. Assemble, catalogue and automate access to literature relating environmental management to stream water quality. Develop and document a rationale for water quality monitoring plans.

Approach: Investigate the relationship between stress quality, wetland function, and precipitation chemistry and the relationship between organic matter and geomorphology. Determine the potential value of those relationships as predictors of water quality under different management strategies and precipitation quality regimes. Compile an indexed bibliography of recent cold spring literature.

Progress: 84/01 to 84/12. (1) Water quality is an integral part of overall watershed resource assessment and management. Accurate and defensible watershed management decisions require a solid base in a disciplinary perspective, and an involvement of scientists from a series of disciplines. This is especially true in areas with a complex of forest and agricultural land use. (2) This project is designed to provide the water quality element of integrated interdisciplinary watershed management efforts. To that end, we have pursued specific projects which provide the base for the detection of impacts, and interdisciplinary projects which provide the integration. In the former category are works on the cycling of carbon and phosphorus in aquatic systems, innovative tools for measuring biology impacts, and effects of acid deposition on lower trophic levels. These elements all seek to provide answers to the question: what are the specific impacts of alternative water quality management strategies? (3) The interdisciplinary integration is provided through several team approaches to water resource management; e.g., a team evaluation of Thai watershed management, a team approach to water quality management in Southeast

Minnesota, and pending watershed work in India and other parts of Asia.

Publications: 84/01 to 84/12

- PERRY, J.A., SCHAEFFER, D.J., KERSTER, H.K. and HERRICKS, E.E. 1984. The environmental audit II: Application to stream network design. Environmental management, In Press.
- PERRY, J.A. 1984. The Dillor Hypothesis of Titular colonicity: An empirical test from the ecological sciences. Journal of the American Society for Information Science, In Press.
- PERRY, J.A. 1984. Preliminary design of a water quality monitoring exercise with simulated historical records. Journal of the National Association of College Teachers of Agriculture. 28(4)20-22.
- SCHAEFFER, D.J., KERSTER, H.K., PERRY, J.A., SOKOLIK, S.K. and COX, D.K. 1984. The environmental audit I: Concepts. Environmental Management. In press.
- PERRY, J.A. 1984. No Halo for HALO and SURF is not golden: A review of two graphics packages. Science Software Quarterly 1:64-73.

03.016 CRIS0068955
**ACIDIC RAIN: REGIONAL RAIN CHEMISTRY & LONG
 RANGE TRANSPORTED VS. LOCAL SOURCE EMITTED
 POLLUTANTS**

KRUPA S V; Plant Pathology; University of Minnesota, St Paul, MINNESOTA 55108.
 Proj. No.: MIN-22-074 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 82 to 30 JUN 83

Objectives: To determine the major inorganic ion composition of individual rainfalls in Minnesota; to apply appropriate numerical analyses to predict the association of sulfate and nitrate with various cations, including hydrogen; to separate rainfalls preceded by long range pollutant transport (LRTAP) from those governed by local meteorological processes, through the use of reverse air parcel trajectory analyses; and to estimate from objective 3, the contributions of LRTAP vs. local processes to the nature of rainfall and its acidity.

Approach: Individual rainfalls will be collected during the summer at selected sites in Minnesota using an automatic, refrigerated, sequential, sampler. These samples will be analyzed for major anions and cations. The anions, SO²⁻(4) and NO³⁻(3) will be examined mathematically for their association with hydrogen (acidity) and other cations. Rainfalls with different values of pH and SO²⁻(4) and NO³⁻(3) concentrations will be related to daily reverse air parcel trajectories to separate LRTAP vs. local influences as they relate to sulfate and nitrate concentrations in the individual rains. Further, these processes will be related to NH⁴⁺(4) in the rainfall.

Progress: 84/01 to 84/12. The impacts of a scrubbed plume from a coal-fired power plant on the terrestrial vegetation in the vicinity, were investigated over a period of 10 consecutive summers. Ground level sulfur

dioxide concentrations at eight isopleths were mostly below 26 ug/m /hr and never exceeded 390 ug/m /hr. About 75% of the sulfate and nitrate in the rainfall was in a non-acid form, and was influenced by long range transport, as evidenced by back trajectory analysis.

Vegetation in the vicinity of the source exhibited foliar sulfur accumulation due to the atmospheric inputs, for the first three years, after which it leveled off. The vegetation appeared to have compensated for the soil sulfur deficiency through atmospheric inputs. This was confirmed by using S and boron as tracers of the source plume. No trends in soil chemistry were found during the 10 year period. Farming practices appear to be a more important factor in this context. The atmospheric sulfur inputs did not result in crop productivity changes in soybean. On the other hand, the low sulfur dioxide inputs resulted in a reversal of the effects of ozone on soybean yield.

Publications: 84/01 to 84/12

KRUPA, S.V. 1984. Field exposure methodology for assessing the effects of photochemical oxidants on crops. Proc. Ann. Air Pollut. Control Assoc. San Francisco, CA. 84:104. 2:1-13.

KRUPA, S.V. 1985. Impacts of scrubbed plume from a coal-fired power plant on terrestrial vegetation. Perspectives in Environmental Botany. (In press).

03.017 CRISO000155
IMPACT OF FOREST MANAGEMENT ON NUTRIENTS IN SOIL AND WATER

PIERCE R S; FEDERER C A; HORNBECK J W;
Northeastern Forest Expt Stat, Durham, NEW HAMPSHIRE 03824.
Proj. No.: NE-1601 Project Type: INHOUSE
Agency ID: FS Period: 11 MAY 65 to

Objectives: Provide adequate information on the effects of timber-harvesting practices on soil nutrients in northern hardwoods. Quantify the impact of forest management practices on stream chemistry, especially in terms of water quality standards and stream biota.

Approach: Nutrients in whole-tree biomass, soil, and inputs and outputs in experimental plots and watersheds will be examined to determine the impacts of harvesting and length of cutting rotations on possible site degradation. Changes in chemical parameters of streams such as major cations, anions, pH, and conductivity as well as sedimentation for selected examples of various harvesting operations will be determined.

Progress: 82/10 to 83/09. Clearcutting and whole-tree harvesting in northeastern forests can cause losses of nitrogen from the forest soil by the processes of product removal, leaching, and denitrification. If the lost nitrogen is not replaced from the atmosphere over the next rotation, reduced nitrogen availability may reduce forest productivity. Foresters need to know management strategies that will affect productivity over the next hundred years. Simulation models offer the only

means of quantifying knowledge and using it to make forecasts. A model productivity as limited by nitrogen over 100 years has been developed by Forest Service and cooperating scientists of the Hubbard Brook Ecosystem Study. The model implies that whole-tree harvesting on long (90-year) rotations will maintain productivity, while short (30-year) rotations will cause lower productivity. The model does not yet include nitrogen mineralization in mineral soil, and denitrification, because too little is known of these processes. The continuous record of precipitation chemistry at Hubbard Brook Experimental Forest now spans 18 years--the longest in North America. During this period there has not been a significant change in acidity of precipitation, but there have been important changes in the overall chemical composition. Acid precipitation is primarily the result of dissociation of sulfuric ($H(2)SO(4)$) and nitric ($HNO(3)$) acids.

Publications: 82/10 to 83/09

NO PUBLICATIONS REPORTED THIS PERIOD.

03.018 CRISO090587
GENETIC CHANGES ASSOCIATED WITH THE ACIDIFICATION OF A FOREST WATERSHED

BRUSSARD P F; Ecology and Systematics Sec;
Cornell University, Ithaca, NEW YORK 14853.
Proj. No.: NYC-183567

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 JUN 83 to 30 SEP 86

Objectives: *Daphnia middendorffiana* is a key organism in food chains in high altitude forest watersheds in the Colorado Rockies, and genetic diversity in this species consists solely of coexisting, noninterbreeding clones. Increasing acidification of these watersheds is occurring as a result of acid precipitation. This investigation will study the expected loss of clonal diversity which is likely to occur in *Daphnia middendorffiana* populations as acidification proceeds.

Approach: These studies will be conducted in the Mexican Cut/Galena Mountain Research Preserve and nearby areas in Pitkin and Gunnison Counties, Colorado. The patterns of physical, chemical, and biological change in this watershed resulting from increasing levels of acid precipitation have been documented at Mexican Cut since 1980. *Daphnia middendorffiana* populations will be sampled from Mexican Cut ponds throughout the icefree season, and their clonal composition will be determined by starch- and acrylamide-gel electrophoresis. The detailed ecological information available from the Mexican Cut watershed project will allow me to test the hypothesis that changes in clonal diversity in *D. middendorffiana* are related to changes in environmental parameters resulting from increased acidification.

Progress: 84/01 to 84/12. *Daphnia middendorffiana* populations were found to exist in 6 of the 17 ponds in the Mexican Cut watershed on the western slope of the Rocky Mountains in Colorado. Laboratory culture of individuals collected from these populations

was attempted without success. Culture was then attempted by isolating individuals in containers suspended within their native ponds; this proved to be successful, and 25 clones from each of the 6 ponds were frozen for electrophoretic analysis. An enzyme screen for this species has already been completed at the Cornell Laboratory for Ecological and Evolutionary Genetics, and the 150 clones collected during the field season will be subjected to electro-phoretic analysis at 20 loci during the spring of 1985.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

03.019* CRIS0089623
ALUMINUM-LIGAND INTERACTIONS IN A FORESTED ECOSYSTEM, PRIOR AND FOLLOWING CLEARCUTTING

MITCHELL M J; School of Biology Chem & Ecolo; State University of New York, Syracuse, NEW YORK 13210.

Proj. No.: NYZ-2360-01-002 Project Type: STATE Agency ID: OCI Period: 15 JUL 82 to 31 DEC 84

Objectives: To evaluate the response of soil and solution chemistry to whole-tree harvesting, specifically by evaluating the mechanisms that control the interactions between the sulfur and nitrogen cycles and aluminum cycling and the mechanisms by which aluminum influences other elemental cycles.

Approach: Streams, groundwater, and soil in two adjacent watersheds--one of which will be clearcut in 1983--will be sampled periodically and analyzed for critical parameters. Laboratory titration will indicate the soils' responses to strong acids. A chemical equilibrium model will be used to analyze all collected data.

Progress: 83/10 to 84/09. Sulfur constituents were measured in samples from 16 pits at three elevations at Hubbard Brook, New Hampshire. Carbon-bonded sulfur, ester sulfate, sulfate, reduced non-sulfate inorganic sulfur, and total sulfur were determined on all samples. Concentrations of all constituents varied among pits, but generally similar to a hardwood site studied at the Huntington Forest, New York, with organic horizons dominating. Dynamics of sulfur were examined by adding S-SO₄ to three horizons. Incorporation of sulfate into organic sulfur forms was found to be an important process and was dependent on horizon characteristics. Adsorption of sulfate dominated in the Bh and to a greater extent in the Bsl horizons. The influence of immobilization-mineralization and adsorption-desorption reactions on S movement through forest soils was evaluated.

Publications: 83/10 to 84/09

FULLER, R.D., DAVID, M.B. and DRISCOLL, C.T. 1984. Sulfate adsorption relationship in some forested spodosols of the northeastern U.S. Soil Sci. Soc. Amer. J. (in press).
 SCHINDLER, S.C., MITCHELL, M.J., SCOTT, T.J., FULLER, R.D. and DRISCOLL, C.T. 1984. Incorporation of S-sulfate into inorganic

and organic sulfur constituents of two forest soils (in review).

03.020* CRIS0080035
IMPACTS OF FOREST LAND USE ON WATER QUALITY IN NORTH CAROLINA

GREGORY J D; Forestry; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
 Proj. No.: NC03691 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 85

Objectives: Develop a physiographic system of classifying forest habitat regions in North Carolina that will be applicable to both site quality and hydrologic characteristics, conduct a problem analysis of specific data needs for natural water quality and for pollution resulting from silvicultural activities, and implement priority field studies identified in the analysis.

Approach: Tentative forest habitat regions have been delineated on imagery and will be further refined by incorporating geologic, soils, hydrologic, and climatic data. Regions will be ranked according to potential for water pollution related to forestry activities and prioritized for further study. An extensive problem analysis will be utilized to define and prioritize research needs in the area of forestry and water quality. Field studies will be designed and implemented to address the highest priority questions identified.

Progress: 84/01 to 84/12. This project was extended to September 1985 to allow completion of a study of the relationship of turbidity to suspended sediment concentration in small Piedmont streams. Grab samples have been collected during the year and preliminary regressions have failed to show a strong correlation between sediment concentration and turbidity. A runoff measurement station has been installed with a stage actuated water sampler in order to collect a number of samples across each stormflow hydrograph. Planning is underway for a new project on forest water management in the lower Coastal Plain. Preliminary field work has been initiated for two studies in cooperation with the International Paper Company and the North Carolina Forest Service. The first experiment will determine the influence of drainage ditch spacing and water control on water table behavior and tree growth. The second study is a long-term paired watershed experiment to determine the hydrologic impacts of drainage. GRADUATE STUDENTS = 2.

Publications: 84/01 to 84/12

BLANK, G. B., DILLON, P. J. and GREGORY, J. D. 1984. Hydrology. pp. 427-433. In: The Acidic Deposition Phenomenon and Its Effects: Vol. II. Effects Sciences. Critical Assessment Review Papers. USEPA.
 GREGORY, J. D. 1984. Forestry-processing and field water management. Sec. IIC. pp. 39-46. In: Assessment of available water resources, water issues and future demands. Report of the Water Conservation and Utilization Task Force.

- GREGORY, J. D. 1984. Water management for silviculture in the lower Coastal Plain. Paper presented to Annual Conference of the National Council on Air and Stream Improvement for the Pulp and Paper Industry. Atlanta, GA, May 30, 1984.
- GREGORY, J. D. 1984. Availability and demands for water in forestry. N.C. Chapter, SCSA, Annual Meeting. June 15- 16, 1984. Raleigh, NC.

03.021 CRIS0000161
**WATER, SOIL, AND AQUATIC RESPONSES TO
 MANAGEMENT OF SOUTHERN APPALACHIAN-PIEDMONT
 FORESTS**

SWANK W T; SWIFT L W JR; WAIDE J B;
 Southeastern Forest Expt Station, Franklin,
 NORTH CAROLINA 28734.
 Proj. No.: SE-1651 Project Type: INHOUSE
 Agency ID: FS Period: 17 MAR 76 to 09 OCT 86

Objectives: To evaluate and explain how water and aquatic resources respond to intensive management of Southern Appalachian and Piedmont forests and to identify management practices which protect these resources.

Approach: Basic and applied research will be conducted on forested plots and watersheds to determine the flux of water, nutrients, and pollutants and to relate these fluxes to productivity of terrestrial and aquatic ecosystems. From the knowledge gained from these studies, techniques for safely managing soil, water, and aquatic resources will be formulated and tested.

Progress: 83/10 to 84/09. Sulfate has been identified as a major constituent of acid precipitation in several regions of the United States. However, the fate of this exogenous sulfate in forest ecosystems is not well known. Recent studies at Coweeta Hydrologic Laboratory in the Southern Appalachians have shown that microbial populations in forest floor and soil rapidly metabolize inorganic sulfate into organic forms of sulfur. Annual rates of incorporation can exceed atmospheric inputs of sulfate and this process of organic sulfate formation accounts for part of the apparent sulfur accumulation in forest soils. Moreover, the presence of this biological pathway in the sulfur cycle of a forest provides a buffer against the impacts of acid precipitation on forest soils by reducing the mobility of sulfate, which in turn, reduces nutrient leaching. A comparison of water chemistry in white pine, pitch pine, and mixed hardwood forests showed that the forest canopy, litter, and upper 25 cm of soil are major compartments of ion exchange in each of these forests. Hydrogen ions delivered in acid precipitation are depleted within these compartments through exchange with other cations; by the time precipitation reaches the stream, pH values increase (less acid) nearly 2 pH units. These findings clearly illustrate the buffering influence of forests on substances derived from atmospheric deposition, such as acid precipitation.

Publications: 83/10 to 84/09

- SWANK, W.T., FITZGERALD, J.W. and ASH, J.T. 1984. Microbial transformations of sulfate in forest soils. *Science* 223:182-184.
- SWANK, W.T. and SWANK, W.T.S. 1984. Dynamics of water chemistry in hardwood and pine ecosystems. In: T.P. Burt and D.E. Walling (eds.) *Catchment experiments in fluvial geomorphology*. Proc. Int. Geogr. Union Comm. on Field.
- SWANK, W.T. 1984. Atmospheric contributions to forest nutrient cycling. *Water Resour. Bull.* 20:313-321.
- SINGER, F.J., SWANK, W.T. and CLEBSCH, E.E.C. 1984. Effects of wild pig rooting in a deciduous forest. *J. Wildl. Manage.* 48:464-473.
- BORING, L.R. and SWANK, W.T. 1984. Symbiotic nitrogen fixation in regenerating black locust (*Robinia pseudoacacia* L.) stands. *For. Sci.* 30:528-537.

03.022* CRIS0093520
**THE ECONOMICS OF RESIDUALS: SOIL EROSION AND
 SEDIMENT; SLUDGE AND SOLID WASTE; ACID RAIN**

FORSTER D L; SOUTHGATE D JR; HITZHUSEN F J;
 Agri Economics & Rural Sociol; Ohio State
 University, Columbus, OHIO 43210.
 Proj. No.: DH000780 Project Type: HATCH
 Agency ID: CSRS Period: 01 AUG 84 to 31 OCT 87

Objectives: Explore the economics of technically viable options for controlling soil erosion and sediment deposition in the East Fork of the Little Miami River Basin (Southwestern Ohio) and the Valdesia Watershed (Dominican Republic), recycling sludge, metals and other valuable residuals, and reducing both source emissions and receptor damage from acid rain.

Approach: The analysis of soil erosion and sediment control requires estimates of costs and benefits for three groups - farmers, downstream water users, and future generations of producers. Also, options for controlling erosion may impact regional economics, and these will be investigated through regional input-output models. Analysis of recycling sludge and other residuals requires estimates of benefits and costs. The focus will be economies of size in composting plants and the effect of composting on wastewater treatment costs. Cost effectiveness estimates will be made for options to control acid rain. Also, institutional mechanisms for dealing with the spillover aspects of acid rain will be inventoried.

Progress: 84/08 to 84/12. D. Southgate was one of two principal investigators on a study of the feasibility of using heat generated at the Piketon, Ohio uranium enrichment facility to heat a greenhouse complex. Five faculty members and three graduate students participated in the study, which was funded by DOE. In addition to the final report, manuscripts based on project research have been submitted to *J. Am. Soc. Hort. Sci.* and *J. Northeastern Ag. Econ. Council*. Articles describing research on third world soil erosion

problems written by Doug Southgate, Fred Hitzhusen, and others have appeared or will shortly appear in Am. J. Ag. Econ., Land Econ., and Water International. Papers on the same topic were presented at the East-West Center and at annual meetings of the Am. Ag. Econ. Assoc., and the Soil Conservation Society of America. Forster's work in the area of soil erosion and sediment has resulted in two manuscripts being accepted for publication. One reported the results of six years of work in the Lake Erie Basin. It describes a program to reduce pollutant loads to Lake Erie. The other manuscript reports estimates of off-farm costs of oil erosion in northwestern Ohio.

Publications: 84/08 to 84/12

FORSTER, D.L. and ABRAHAM, G. 1985. "Sediment deposits in drainage ditches: a cropland externality," Journal of Soil and Water Conservation.

FORSTER, D.L., LOGAN, T.J., YAKSICH, S.M. and ADAMS, J.R. 1985. An accelerated implementation program for reducing diffuse source phosphorus load to Lake Erie. Journal of Soil and Water Conservation.

03.023* CRISO087736
ECONOMICS OF NATURAL RESOURCE UTILIZATION
POLICY WITH EMPHASIS ON PACIFIC NORTHWEST LAND
& WATER

MCCARL B A; OBERMILLER F W; Agri & Resource Economics; Oregon State University, Corvallis, OREGON 97331.

Proj. No.: ORE00121 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 82 to 30 JUN 87

Objectives: To improve the quality of policy decisions relating to the use of Pacific Northwest (PNW) land and water resources. Analyze trends in the usage of PNW resources, particularly by agriculture, forestry, and fisheries; Examine the influence of policy on these trends; Identify the effects of changes in policy on economic efficiency and distributive equity; Identify key factors, constraints, and conflicts which influence natural resource supported economic development in the PNW; Analyze issues of current and/or foreseeable future interest providing information on the consequence of potential policies.

Approach: Analytical models will be developed for examination of PNW resource policy questions. These models will be used to predict effects of resource policy. The models and model development process will also facilitate understanding and analysis of policy options.

Progress: 84/01 to 84/12. New irrigation development above Grand Coulee Dam on the Columbia was found to be as costly as \$200 per acre per year electricity consumers and society. However, this cost was found to be greatly reduced if irrigators were allowed to a) develop lands further downstream; b) divert water only in noncritical flow years; or c) pay the full cost of pumping. The current system for charging for grazing fees was found to be inferior to one based on the private land lease

rate in preventing future discrepancies. Further, it was found that the total social value of grazing lands could only be increased by lowering fees not by increasing them. The increases basically transfer money from ranchers to the public. The changes in the Canadian exchange rate between 1975 and now were found to be important determinants in the increasing share that Canadian lumber constitutes of the U.S. lumber market. U.S. agriculture was found to be the most affected sector by ozone air pollution. A 10% reduction in ambient ozone was predicted to have a \$0.76 billion cost to society while 25% and 40% reductions were found to exhibit \$1.94 billion and \$2.86 billion cost increases, respectively. A 25% increase in ozone would lead to a predicted \$2.36 billion cost in ozone. Changes in the location of export elevators was not found to be an efficiency increasing alteration. Ocean shipping rates were found to be a significant factor in determining grain shipping patterns.

Publications: 84/01 to 84/12

NELSON, C.H. and MCCARL, B.A. Including Imperfect Competition in Spatial

Equilibrium Models. Canadian Journal of Agricultural Economics 32(1)1984:55-70.

ALI, I., BARNETT, D., KENNINGTON, J., MCCARL, B., PATTY, B., SHETTY, B., and WON, P.

Multicommodity Network Problems: Applications and Computations. IIE Transactions, June 1984:127-134.

BARNETT, D., BINKLEY, J. and MCCARL, B. Port Elevator Capacity and National and World Grain Shipments. Western Journal of Agricultural Economics 9(1984):77-89.

MCCARL, B. and HAYNES, R. Exchange Rates and Softwood Lumber Trade. Journal of Forestry 1984.

MCCARL, B., ARTHUR, J., KENNINGTON, J. and POLITO, J. SEBEND: A Computer Algorithm for the Solution of Symmetric Multicommodity Spatial Equilibrium Problems Utilizing Benders Decomposition. OSU Special Report 708, 1984.

03.024* CRISO095439
H+ BUDGETS AND ECOSYSTEM ACIDIFICATION: CASE
STUDIES OF RED ALDER AND DOUGLAS-FIR ECOSYSTEMS

SOLLINS P; BINKLEY D E; Forest Science; Oregon State University, Corvallis, OREGON 97331.

Proj. No.: ORE-FS-392-S Project Type: STATE
 Agency ID: OCI Period: 01 FEB 85 to 31 JUL 87

Objectives: To construct H budgets for pairs of pure conifer and nitrogen-fixing red alder/conifer stands at two locations in the Pacific Northwest.

Approach: One location H+ highly fertile and soil acidity has increased under alder. The other location is less fertile, and no change in soil acidity can be detected. The importance of our project lies in two directions. First, the enhancement of soil fertility by N-fixing alder may in part be offset by "natural" acidification and leaching losses of cation nutrients. Second, the internal H generating and absorbing processes of forest ecosystems

are major variables involved in determining the effects of atmospheric inputs of H⁺. Our research would serve to elucidate the mechanisms regulating soil acidification beneath alder and also provide a framework for comparing long-term natural acidification with the effects of increased H⁺ inputs from acid precipitation.

03.025 CRIS0022524
FOREST AMENITIES & MUNICIPAL WATERSHEDS

HALVERSON H G; CORBETT E S; HEISLER G M;
Northeastern Forest Experiment Station;
Pennsylvania State University, University Park,
PENNSYLVANIA 16802.
Proj. No.: NE-1651 Project Type: INHOUSE
Agency ID: FS Period: 12 APR 82 to 12 APR 87

Objectives: To determine the effects of trees and woodlands on residential fuel requirements and noise levels in populated areas; to develop methods for improving water quality in multiple use municipal watersheds subjected to acid precipitation; to determine water and nutrient cycle impacts on urban forest vegetation.

Approach: Energy requirement and sound attenuation studies will deal with wind patterns, radiant energy fluxes, and physical principles of sound attenuation as affected by urban forest vegetation. Quality water production under multiple uses on municipal watersheds will involve the effects of forest management prescriptions, human activity, and atmospheric deposition. Water and nutrient cycle impacts on urban and community forests will deal with water stress on urban trees, the impact of atmospheric deposition, and related edaphic effects. Unit research on the effect of forest vegetation on the urban environment will be coordinated with research in the Consortium for Environmental Forestry Studies. This is a multi-functional research work unit.

Progress: 83/10 to 84/09. Trees around buildings may either increase or decrease energy use for heating and cooling depending on tree form and arrangement. In an experiment over most of heating season, the effect of a single-row windbreak on rate of air infiltration and energy use in a small mobile home was evaluated. Air infiltration was reduced by an average of 54% when the windbreak was 1 tree-height from the home. Heating energy use was reduced by 18 and 17% at 1 and 2 tree heights. Three aspects of hydrometeorological significance: quality precipitation, the watershed response converting precipitation into streamflow, and the change in streamflow quality, were studied on a forested experimental watershed in central Pennsylvania. Predictive equations were developed for estimating changes in pH, acidity, and alkalinity expected to occur during future stormflows. The independent hydrologic variables which were most highly correlated with changes in H⁺, alkalinity, and acidity were: rainfall recorded prior to a specific

precipitation event, antecedent streamflow rate, peak flow rate, quickflow volume, and the storm's precipitation amount. Throughfall chemistry can be considerably different than precipitation chemistry. However, there is little information available on the effect of different hardwood species or the portion of the crown that is contacted by the precipitation.

Publications: 83/10 to 84/09.
CORBETT, E.S.; LYNCH, J.A. 1983. Rapid fluctuations in streamflow pH and associated water quality parameters during a stormflow event. In: International symposium on hydrometeorology. 1982 June 13-17; Denver, CO; Bethesda, MD.
DEWALLE, D.R.; HEISLER, G.M. 1983. Windbreak effects on air infiltration and space heating in a mobile home. *Energ. Build.* 5:279-288.
EDWARDS, P.J.; HALVERSON, H.G.; DEWALLE, D.R. 1983. Changes in precipitation chemistry yielded to urban runoff by tree crowns. In: 1983 International symposium on urban hydrology, hydraulics and sediment control. 1983 July 25-28.
HEISLER, G.M.; DEWALLE, D.R. 1984. Technical update: Tree management for energy savings. *Nat. Urban Community For. Forum* 4(4):5-6.
HORNBECK, J.W.; CORBETT, E.S. DUFFY, P.D. LYNCH, J.A. 1984. Forest hydrology and watershed management. In: *Forestry handbook*. New York, NY: John Wiley and Sons;

03.026 CRIS0076853
INFLUENCE OF ACID PRECIPITATION ON PH AND ACIDITY OF SMALL HEADWATER STREAMS IN PENNSYLVANIA

CORBETT E S; LYNCH J A; School of Forest Resources; Pennsylvania State University, University Park, PENNSYLVANIA 16802.
Proj. No.: PEN02449
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 DEC 79 to 30 SEP 83

Objectives: Determine influence of acid precipitation on streamwater pH and acidity from forested and clearcut watershed in central Pa. Determine if streamwater pH and acidity are influenced by precipitation. Determine joint variability of precipitation pH and acidity; stormflow pH and acidity during storm events.

Approach: Fluctuations in streamwater pH will be monitored using continuous recording pH meters. Routine sampling of streamflow plus stormflow samples taken with sequential water samplers will provide the basis for assessing fluctuations in stream acidity. Stream acidity and pH will be monitored throughout the growing and dormant seasons. Data will be analyzed to determine if a relationship exists between precipitation pH and acidity and streamflow pH and acidity and whether these relationships are influenced by storm characteristics and/or season. A sequential collection unit will be used to collect precipitation samples during the early, middle, and later stages of rainfall. Data collected from these samples

will be compared with selected storm characteristics as well as pH and acidity data obtained from stormflow sampling.

Progress: 79/12 to 83/09. Acid precipitation was found to significantly influence the chemistry of small streams in central Pennsylvania. Stream discharge on the Leading Ridge Experimental Watersheds was sampled using sequential water samplers and continuous recording pH meters. Samples from 19 storms were analyzed for pH, alkalinity, and acidity levels. Precipitation varied considerably in amounts, durations, and intensities and produced highly variable hydrologic responses. Stream pH and alkalinity levels were found to be inversely related to stream discharge, with their lowest levels occurring almost simultaneously with peak runoff. The average pH drop was 0.6 units. Alkalinity dropped an average of 160 ueq/l. Stormflow acidity was directly related to discharge, with the peaks nearly coinciding. The largest storm monitored resulted in a 2.4 unit decline in stream pH; hydrogen ion concentration increased 200 times. Stream alkalinity was completely depleted and recovery delayed for more than a week. The observed changes in stream quality could not be associated with any other source of acidity and were highly correlated with storm hydrograph parameters which describe the amount and rate at which precipitation reaches a stream. The results of this study also indicate that considerable inter- and intra-watershed variation existed in the response of stream chemistry to acid precipitation.

Publications: 79/12 to 83/09

CORBETT, E. S., LYNCH, J. A. 1982. Rapid fluctuations in streamflow pH and associated water quality parameters during a stormflow event. Proc. Int Symp. on Hydromet. Denver, CO., 1982. Am. Water Res. Assoc. pp. 461-464.

HANNA, C. M. 1983. Watershed responses and stormflow chemistry changes following precipitation in central Pennsylvania. M.S. Thesis. Pennsylvania State University. University Park, PA 100p.

LYNCH, J. A. Atmospheric deposition and stream ecosystems: Constraints in assessing relationships. In: Proc. Symp. on Air Pollution and the Productivity of the Forest. Washington, D.C., October 4-5, 1983.

03.027 CRIS0094567
CYCLING ATMOSPHERIC DEPOSITION THROUGH A FORESTED WATERSHED -- CHANGES IN SOME CRITICAL COMPONENTS

LYNCH J A; School of Forest Resources; Pennsylvania State University, University Park, PENNSYLVANIA 16802.
Proj. No.: PEN02773

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 JAN 85 to 31 DEC 86

Objectives: Qualify and quantify changes in soil water and streamflow chemistry due to atmospheric deposition during storm events. Evaluate a means of quantifying the

contribution of dry deposition to the chemistry of bulk precipitation reaching the soil surface beneath a forest canopy.

Approach: Precipitation quality will be monitored sequentially above and below the canopy during rainfall events. These data will provide the basis for assessing the importance and measurements of dry deposition and for determining the quality of throughfall chemistry as it enters the soil. Samples from pan lysimeters and ground water wells will be used to monitor fluxes in soil water chemistry. Soil water will be sampled sequentially in unison with streamflow. Water quality data will be evaluated to determine the importance of each component of the hydrologic cycle in determining stream chemistry during storm events.

03.028 CRIS0000156
WATER RESOURCE PROTECTION IN CENTRAL APPALACHIANS

HELVEY D; KOCHENDERFER J N; USDA Forest Service, Parsons, WEST VIRGINIA 26287.
Proj. No.: NE-1602 Project Type: INHOUSE
Agency ID: FS Period: 08 AUG 72 to 23 DEC 85

Objectives: For Central Appalachian forest areas to develop management guidelines for minimizing hydrologic impacts caused by forest access and harvesting and, secondly, to quantify the effects of atmospheric deposition on the soil and water resources.

Approach: To develop management guidelines for minimizing hydrologic impacts caused by forest access and harvesting: Measure soil loss and utility of forest roads constructed to varying standards over the range of soil conditions common to the Central Appalachians. Determine how much sediment reaches stream channels. To quantify the effects of atmospheric deposition on the soil and water resources: Measure chemical properties of water samples collected at various points in the hydrologic cycle, e.g., incident rainfall, throughfall, ground water, and streamflow. Define chemical changes as water moves through the ecosystem. Determine how values within a given ecosystem change with time (season), and how soil and geologic types influence the values. Develop long range predictions of how these values will change under various assumed levels of rainfall acidity.

Progress: 83/10 to 84/09. Forest access roads are a major concern of land managers in the Appalachian Mountains because of construction costs and sediment contribution to streams. Detailed sediment losses and construction costs were evaluated for 8 forest roads in the central Appalachians. Results of the study were used to develop specifications for a minimum-standard logging road--a road that provides needed utility while controlling soil losses. The minimum-standard road concept has been adopted by private land owners, state and county foresters, and several National

Forests. A summary of 812 forest soil erosion studies across the United States showed unexpected uniformity among sites. Only the streams draining forested land along the Pacific coast showed significantly more sediment yield than elsewhere in the country. Excluding the West coast, about 1/3 of the observations denoted sediment yields not exceeding 0.02 ton per acre per year. About 1/4 fell between 0.25 and 1.00 ton, and a few exceeded 1.00 ton per acre annually. A study defined spatial and seasonal variability in soil acidity within an undisturbed watershed on the Fernow Experimental Forest between 1979 and 1982. Soil pH averaged 4.3, 4.6, and 4.7 at the A, B, and C horizons, respectively. There was no consistent trends between soil pH averages by seasons. These data will be useful for interpreting other data, such as long term stream chemistry changes, collected from the same watershed.

Publications: 83/10 to 84/09

- HELVEY, J.D. 1984. Reply to "Discussion" by John A. Kay. "Sampling accuracy of pit vs. standard rain gages on the Fernow Experimental Forest". Water Resources bull. 20(2) :277-278.
- KOCHENDERFER, J.N. and HELVEY, J.D. 1984. Soil losses from a "minimum-standard" truck road constructed in the Appalachians. In: Proc. Mountain Logging Symp., Morgantown, WV; West Virginia University, p. 215-225.
- KOCHENDERFER, J.N.; WENDEL, G.W. and SMITH, H.C. 1984. Cost of and soil loss on "minimum-standard" forest truck roads constructed in the Central Appalachians. Res. Pap. NE-544. Broomall, PA: USDA, For. Service, Northeastern For. Exp. Sta.
- PATRIC, J.H.; EVANS, J.O. and HELVEY, J.D. 1984. Summary of sediment yield data from forested land in the United States. J. Forestry 82(2) :101-103.
- TOMKOWSKI, A.C. 1983. A study of the effects of acid rainfall on forest soil acidity. Forestry Notes; West Virginia University, Agricultural and Forestry Experiment

03.029 CRIS0080601
ACID RAINFALL EFFECTS ON FOREST SOILS

TOMKOWSKI A C; Forestry; West Virginia University, Morgantown, **WEST VIRGINIA** 26506.
Proj. No.: WVA00191 Project Type: STATE
Agency ID: SAES Period: 30 SEP 79 to 31 DEC 82

Objectives: Characterize pH throughout the profiles of soil types on watershed 4 a permanently forested control watershed on the Fernow Experimental Forest.

Approach: These observations will be repeated at 5 to 10-year intervals.

Progress: 79/09 to 82/12. The final report for this project will be submitted for review on December 3, 1982. The finalized report will be turned in, and this phase of the project terminated by December 31, 1982. Although interpretation of this data showed considerable variation in soil pH, statistical analysis showed no significant differences except

between horizons, which was expected. Other parameters tested, for correlations in pH, were horizon-year, site-horizon, site-horizon-year, horizon-season, and horizon-year-season interactions. Samples were analyzed for P, K, Ca, and Mg too. However, after four sets of samples were collected and analyzed, this researcher was notified that the laboratory results were not meant to be used for research purposes. With this fact in mind, the analysis for these elements was not included in this report. More data needs to be collected to see whether or not acid inputs into the system are in fact responsible for decreases in soil pH.

Publications: 79/09 to 82/12

NO PUBLICATIONS REPORTED THIS PERIOD.

03.030* CRIS0000005
ENVIRONMENTAL HYDROLOGY OF THE CALIFORNIA SNOW ZONE

BERG N; MCGURK B; Pacific Southwest Forest and Range Experiment Station; Medical College of Wisconsin, Milwaukee, **WISCONSIN** 53226.
Proj. No.: PSW-1601 Project Type: INHOUSE
Agency ID: FS Period: 20 JUN 84 to 20 JUN 89

Objectives: To determine hydrologic principles of snow accumulation and melt, develop guidelines for their use in multiple-use management of the forests of the snow zone of California, and evaluate the role of atmospheric deposition on snowpack chemistry in the Sierra Nevada.

Approach: Physical process models will be developed to improve the estimation of runoff timing and volumes from Sierra Nevada lands where snow melt is a significant water source. The extent of acid deposition in mountainous areas of California will be evaluated through collection and analysis of field data on snow, and soil and surface waters.

Progress: 83/10 to 84/09. The snowpacks of the Sierra Nevada provide a major portion of all water reaching California's streams. Hydroelectric power production, irrigated agriculture and domestic water supply are three major uses of water from the California snow zone. Power company estimates of the equivalent fuel cost attributable to water from the snow zone of the west slope of the Sierra Nevada is in the \$700 to \$900 million range, with a "good" snow year equating to a \$100 million saving in alternate fuel costs. The Research Work Unit is developing improved methods of streamflow estimation, particularly during situations such as rainfall onto the snowpack, that are imperfectly handled by current methodologies. In addition, potential water quality damages resulting from atmospheric deposition are being investigated. Systems for distinguishing between precipitation types have been assessed and a prototype instrument based on a laser technology has been developed. A system for monitoring snowpack liquid water amounts and based upon electrical capacitance is being developed and will be evaluated during fiscal year 1985. Two models estimating snowpack water equivalence, one based upon

historical data and second on snowpack processes, have been developed. These procedures estimate water equivalence over a major basin on the Sierra Nevada's west slope.

Publications: 83/10 to 84/09

- BERG, N.H. and HANNAFORD, M.A. 1983. Application of a snowpack water equivalent model to rain-on-snow events in the central Sierra Nevada. Proc. West. Snow Conf., p. 155-158.
- BERG, N.H., BENEDICT, N. and HARRIS, E. 1984. Environmental aspects of weather modification for snowpack enhancement. Proc. East. Snow Conf., p. 13-23.
- BERG, N.H. and BERGMAN, J.A. 1984. Roadway salting effects on snowmelt water quality. Proc. Specialty Conf., Irrig. and Drain. Div., Amer. Soc. Civ. Eng.: Water--Today and Tomorrow, p. 237-246.
- BERGMAN, J.A. 1983. Hydrologic response of central Sierra Nevada snowpacks to rainfall. Proc. West. Snow Conf., p. 141-144.
- KATTELMANN, R.C., MCGURK, B.J., BERG, N.H., BERGMAN, J.A., BALDWIN, J.A. and HANNAFORD, M.A. 1983. The isotope profiling snow gage: twenty years of experience. Proc. West. Snow Conf. p. 1-8.

03.031*

CRIS0087161

REGIONAL INTEGRATED LAKE-WATERSHED ACIDIFICATION STUDY (RILWAS)

BOCKHEIM J G; Soil Science; University of Wisconsin, Madison, WISCONSIN 53706.
Proj. No.: WIS02710 Project Type: STATE
Agency ID: SAES Period: 01 JUL 85 to 30 JUN 88

Objectives: To monitor the quantity and quality of wet and dry deposition, throughfall, and soil water leachate in various forest types at Round and Eastmile Lakes, northwest Wisconsin, as part of an interdisciplinary study dealing with the effects of acidic deposition on lake chemistry. To study specific mechanisms whereby the terrestrial ecosystem buffers acidic deposition, including foliar leaching, ion exchange, and mineral weathering. To apply the ILWAS Model to predict the effects of acidic deposition on lake chemistry.

Approach: Wet and dry deposition will be collected weekly at each watershed using Aerochem Metric 301 collectors. Nine throughfall collectors have been installed on 4 plots containing representative vegetation at each watershed. Twelve soil water collectors have been located at each of 2 depths (75 and 600 mm) on each plot. All solutions are being analyzed for pH, EC, Al, Si, Ca, Mg, K, Na, NH₄, SO₄, NO₃, Cl, and HCO₃. Temporal changes in tissue concentrations are being measured to determine the relative contributions of foliar leaching and atmospheric deposition to throughfall.

Progress: 84/01 to 84/12. This project is part of an international research program entitled "Regional Integrated Lake-Watershed Acidification Study," funded by the Electric Power Research Institute. The primary objective

of the study is to examine the effects of acidic deposition on biogeochemistry of two watersheds featuring contrasting lakes in northwestern Wisconsin. The findings to date are as follows. Whereas the canopies of deciduous forest types such as birch, aspen, and oak reduce the fluxes of H⁺ ion, SO₄, and NO₃ in bulk precipitation, throughfall from the canopies of coniferous types such as jack and red pines are enriched in these constituents. Although deciduous forest types are able to neutralize acidic deposition, the ultimate source of buffering is in the soil, as determined by a similarity in ion fluxes at the base of the effective rooting zone (60 cm) on plots with and without forest cover. The primary mechanism whereby the soils in northwestern Wisconsin buffer acidic deposition appears to be silicate hydrolysis rather than ion exchange. This is supported by simulated weathering studies conducted on soil columns in the laboratory. Whereas leaching with distilled water (pH 5.6) yielded low amounts of Si and negligible change in pH of the extract, leaching with dilute sulfuric acid (pH 3.0) resulted in large concentrations of Si (2 mg/L) and nearly equivalent reduction in pH of the extract as compared to the leaching solution.

Publications: 84/01 to 84/12

- BOCKHEIM, J.G. 1984. Acidic deposition effects on forest soils and site quality, pp. 19-35. In: Forest responses to acidic deposition. Proc. of the conf., held on Aug. 3-4, 1983, Univ. of Maine, Orono.
- ESSER, J.M. 1984. Biogeochemistry of Quercus and Pinus ecosystems in northwestern Wisconsin. M.S. thesis, Dept. of Soil Science/Forestry, Univ. of Wisconsin-Madison. 103 pp.
- JEPSEN, E.A. and BOCKHEIM, J.G. 1984. Acidic deposition influences on biogeochemistry of four forest ecosystems in northwestern Wisconsin. In: Proc. Sixth Internat. Conf. Environmental Biogeochemistry, Oct. 10-14, 1983.
- BOCKHEIM, J.G., LEIDE, J.E. and ESSER, J.M. 1984. Acidic deposition and ion movements in forest soils of northwestern Wisconsin. In: Proc. Sixth North Amer. Forest Soils Conf., June 20-23, 1983, Knoxville, TN, in press.

CM 04 AIR AND CLIMATE

04.001 CRIS0089431
CHEMISTRY OF ATMOSPHERE DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

STEELE K F; WAGNER G H; Geology; University of Arkansas, Fayetteville, ARKANSAS 72701.
Proj. No.: ARKO1137 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America.

Approach: Maintain the NC-141/NADP atmosphere chemical site at Fayetteville as part of the NADP Network. The program will determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in both wet and dry deposition.

Progress: 84/01 to 84/12. Collection and chemical analysis of wet and dry deposition has continued at Fayetteville utilizing a single atmospheric deposition collector. The weekly wet and eight-week dry samples were shipped to the Central Analytical Laboratory of the National Atmospheric Deposition Program for chemical analyses. Since July 1 the dry deposition samples have been analyzed at the University of Arkansas, Geochemistry Laboratory. The pH values for the year ranged from a low of 4.12 (July 24-31) to a high of 6.70 (April 24 - May 1). There were no major differences in the rain chemistry for 1984 compared to the previous records (three years). Additional research was continued on the effect of dry deposition and rain particulate material on rain chemistry. The importance of particulate material on rain water chemistry is especially obvious for a "Dust-Bowl" rainstorm on 3/17/81. The effect of the particulates on rain pH persisted for rains on 3/17 and 3/21. The pH values (7.1 and 5.3 respectively) for these rains were higher than the yearly precipitation-weighted average 4.8. The Ca contents for both rains were also higher. The main difference between dry deposition and rain particulate material is the presence of 5% calcite in the dry deposition. Thus, the buffering capacity of atmospheric calcite could be the controlling influence on rain pH in certain areas.

Publications: 84/01 to 84/12

WAGNER, G.H. and STEELE, K.F. 1982. Sulfate analyses of rain water using flame emission spectroscopy of barium. Amer. Laboratory. July: 12-25.

WAGNER, G.H. and STEELE, K.F. 1985. Chemical analysis of rain particulate matter: Amer. Laboratory (in press)

04.002* CRIS0089881
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

BURGY R H; CARROLL J J; FLOCCHINI R G; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-4311-RRProject Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America.

Approach: Studies will be conducted to identify and improve efficiency for collection of naturally- and anthropically-generated gaseous and particulate components added to, distributed by and deposited from the atmosphere which may have beneficial or injurious impact on components of terrestrial and aquatic ecosystems. Major sources and composition of atmospheric pollutants and atmospheric processes involved in their distribution and deposition will be investigated.

Progress: 84/01 to 84/12. During 1984, the Davis site operated on a continuous basis to monitor precipitation deposition. This portion of the project is attempting to identify acidic deposition products contained in rain samples and to define the sources of acidic constituents that contribute to acidity of rainfall here. The program was modified on July 1, 1984 to discontinue collections of dry deposition samples (only a few stations in the U.S. will take dry samples hereafter). The Davis site was inspected by NADP this year and minor adjustments in equipment were made to conform to network specifications. A total of 20 rain samples were collected in the year, these yielding pH values ranging from 5.0 to 6.5. The average of all samples is about 5.8 pH units, indicating a nearly neutral acidity in Davis rainfall. Spring rains tend to have higher pH values (about 6.0) and Fall rains tend to be lower (5.0 to 5.5), suggesting some effect due to strong inflow in early winter storms that generally translate into the upper delta area (Davis) from the southwest and include trajectories passing over the metropolitan bay-delta region. The limited numbers of events sampled makes all interpretations inconclusive, and will require longer experience to resolve.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

04.003* CRIS0074466
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

BURGY R H; MYRUP L O; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-3619-RRProject Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establishing an Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Developing optimum procedures for collecting precipitation (regular timed sampling and event sampling) and dry particulate matter (open containers, air-filtration collectors and biological collectors). Determining the stability of certain constituents of precipitation during collection, transport and storage prior to analysis. Investigating the transport and transformations of atmospheric constituents. Organizing and coordinating research in the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition.

Approach: For all objectives listed, utilizing a network sampling station and specifications developed by the Regional Project, the data collection, processing analysis and interpretation will be adapted to project requirements. Special studies are to be devised in concert with project subcommittee coordination.

Progress: 79/09 to 83/09. The data acquisition site in the National Atmospheric Deposition Program has been operational since the Fall of 1979. During the first three years of operation only the rainfall season collections were made in the period of September through May. In 1982, the project operation was made to conform to the NADP standards and schedule with full seasonal data collection made weekly throughout the year. During the five years of records acquired at the station a trend is observable in the measured hydrogen ion concentration (pH) of sampled rainfall, tending to become more neutral with pH approaching 5.6. Occasional samples are measured with both higher and lower pH values. Improvement in the station operating procedures and in the handling and processing both in field and laboratory may account for some reduction in the occurrence of low pH values. Other factors may include improved environmental conditions upwind from the site due to reduced emissions of NO(x) compounds from metropolitan areas and possibly to general shifts in weather phenomena transporting the precipitation products into the region. Based on the record of the site, a general conclusion may be indicated toward low acidic precipitation input in that area of California. The project has been replaced by Inter-Regional Project IR-7, effective October, 1983.

Publications: 79/09 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

04.004

CRIS0066897

URBAN AND RURAL ENVIRONMENTAL QUALITY PROTECTION

MYRUP L O; CARROLL J J; COULSON K L; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-2973-H Project Type: HATCH
Agency ID: CSRS Period: 01 NOV 74 to 30 SEP 84

Objectives: Study the processes determining levels of air pollution. Develop mathematical models of various aspects of the air pollution regime. Improve means for measuring air pollution concentrations. Study the physical and chemical nature of particulates and their effect on atmospheric radiation. Quantify environmental parameters for introduction into the decision-making process.

Approach: The approach will be to make measurements of the amounts and properties of the various pollutants in the atmosphere, as well as their radiative effects, and to utilize these data in arriving at mathematical models of the processes involved.

Progress: 84/01 to 84/12. During the reporting period work continued on the development of improved methodologies to estimate atmospheric particulate transport through the use of principal components analysis. Two techniques were selected for application which use different wind direction variable in an octant-by-octant analysis. The second uses a wind direction pointer and can be used to obtain the fine detail of the wind direction-aerosol loading relationship. These techniques were applied to a data set taken in the Mojave Desert and the following results were achieved: (1) At the Tahachapi site, we have identified nocturnal transport of lead aerosol from the San Joaquin Valley. (2) At the Palmdale site we also detected nocturnal flow of lead aerosol from the direction of Soledad Canyon. (3) At the Cajon site, we identified a non-stability related lead aerosol stream from the direction of the Cajon pass. (4) In addition to aerosols clearly identified with pollution sources, the air above the desert is occupied by a cloud of aerosols derived from crustal elements and apparently aged pollution aerosols. A field experiment was conducted in the late spring and summer of 1984 utilizing a tethered balloon and data from the UCD-SEMRTS weather station to monitor near ground wind and temperature profiles (alt less than 100m).

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

04.005*

CRIS0089880

CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

WHITTIG L D; BURAU R G; HUNTINGTON G L; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-4312-RR Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Studies will evaluate sensitivity of soils, waters, and terrestrial and aquatic organisms to atmospheric deposition, chemical and biological processes in soils, waters and organisms affected by atmospheric deposition, and terrestrial processes and agricultural and forest practices as may influence effects of deposition on aquatic systems.

Progress: 84/01 to 84/12. Investigations under this project contribute to an integrated long-term study of potential impacts of atmospheric deposition on terrestrial and aquatic ecosystems of the Sierra Nevada. Centered in Sequoia National park, this project focuses on buffering characteristics of soils of the program study area, on release of chemical elements from the soils in response to acidity and alkalinity inputs, on mechanisms involved in dissolution and transport of mineral elements and on the input-output balance for sulfuric acid added to the soil systems. A total of 26 surface profile samples from representative soils have been subjected to a buffer performance test involving graded additions of H_2SO_4 and $Ca(OH)_2$. The pH of the systems was measured weekly for 6 weeks to observe the time course of buffering for each profile sample. Aqueous extracts from treated samples have been analyzed for major cations and anions. The pH data have been transformed into van Slyke buffering index curves and apparent sulfate adsorption has been calculated. The mineralogy has been qualitatively determined for silt and clay fractions of 12 of the surface profile samples. Buffering and sulfate adsorption have been unexpectedly strong in many samples while element release has been unexpectedly small. In addition to a wide diversity of phyllosilicate minerals in different soils of the area, there is a relatively high proportion of glass in a number of surface samples, suggesting a volcanic ash deposition source.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

04.006* CRIS0083194
ECONOMIC ANALYSIS OF NATURAL RESOURCE AND
ENVIRONMENTAL ISSUES IN COLORADO

YOUNG R A; WALSH R G; HUSZAR P C; Economics;
Colorado State University, Fort Collins,
COLORADO 80523.
Proj. No.: C0L00328 Project Type: HATCH
Agency ID: CSRS Period: 08 AUG 80 to 30 SEP 83

Objectives: Objectives---The overall objective of the research is to study the demand, supply and economic value of Colorado Natural resources and environmental commodities, and to evaluate market and non-market allocative mechanisms for achieving maximum social return from the resources.

Approach: Analyze the value of water in withdrawal uses (agriculture, households, industries and non-withdrawal uses (recreation); Investigate the economic forces underlying conservation of rural lands to urban uses and evaluate alternative public policies for influencing land use and the extent of urban sprawl evaluate the demand for the management of outdoor recreation on public lands and waters. Evaluate the impact of growing demand for energy on Colorado's economy and environment. Study the economic impacts of natural hazards. Evaluate the economic benefits of air and water quality improvement. Formulate and test new methodologies for ascertaining the economic impacts (in allocative, distributive, and regional dimensions) of changes in the demand for non-marketed environmental goods and services.

Progress: 83/01 to 83/09. The overall objective of this research program is to study the demand, supply and economic aspects of Colorado's natural resources and environmental endowments, to evaluate market and non-market allocation mechanisms for achieving optimal social returns from natural resources, and to assist in conflict resolution via public policy analysis arising from competing uses of these resources. During this time period, research continued on water use allocations and quality aspects, groundwater use in agriculture, an updating of Colorado water case law, option demand for recreational uses, values of hunting and fishing in Colorado, some preliminary work on the grasslands plowout problem in eastern Colorado, and related natural resource economics issues. Due to reorganization of agricultural programs at CSU, a new Department of Agricultural and Natural Resource Economics was established in the College of Agricultural Sciences on July 1, 1983. As a result of this action, this project (Colo 328) is being terminated and will be replaced by a new reoriented research project, "Natural Resource Economics and Regional Resource Allocation Issues", effective October 1, 1983.

Publications: 83/01 to 83/09
DAVITT, G.J. and WALSH, R.G. 1983. A demand function for length of stay on ski trips to Aspen. Journal of Travel Research. 21(Spring).
MCKEAN, J.R. and WEBER, J.C. 1983. The economy of Lincoln, Sublette, Sweetwater and Uinta Counties, Wyoming, Rock Springs BLM District, Technical Report No. 40, Colorado Water Resources Research Institute, Colorado State University.
MCKEAN, J.R. and NOBE, K.C. 1983. 1981 Colorado sportsman survey: Direct and indirect effects of expenditures for hunting and fishing in Colorado (Contract Report for Colorado Division of Wildlife and Bureau of Land Management).

GILLIAM, L.O., MILLER, N.P. and WALSH, R.G.
1983. Congestion and willingness to pay for
expansion of skiing capacity. Land
Economics 59. (May 1983).
GILLIAM, R.A., LOOMIS, J.B. and WALSH, R.G.
1984. Valuing option, existence, and
bequest demands for wilderness. Land
Economics 60. (February 1984).

Environmental Protection Agency Data Management
System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12
NATIONAL ATMOSPHERIC DEPOSITION PROGRAM. 1982.
NADP Instruction Manual: Site Operation.
Beigelow, D.S. (Editor). Natural Resource
Ecology Laboratory, Colorado State
University, Fort Collins, CO. 30 pp.

04.007* CRIS0077142
ATMOSPHERIC DEPOSITION AND EFFECTS ON
AGRICULTURAL AND FORESTED LAND AND SURFACE
WATERS

GIBSON J H; Natural & Environmental Res;
Colorado State University, Fort Collins,
COLORADO 80523.
Proj. No.: C0L02014 Project Type: SPECIAL GRANT
Agency ID: CSRS Period: 03 JUL 78 to 30 SEP 80

Objectives: Establish Atmospheric Deposition
Network to determine spatial & temporal trends
in supply of beneficial nutrient elements &
potentially injurious substances in
precipitation & dry particulate matter.
Determine relative importance of precipitation
& dry particulate matter. Develop optimum
procedures. Determine stability of collection
of precipitation constituents. Investigate
transport & transformations. Organize &
coordinate research in SAES, FS, & other
institutions on the effects of atmospheric
deposition on the productivity of agricultural
crops, forests, range, wet lands, & surface
waters.

Approach: Provide coordination for development
of a program nationally to meet objectives
including organization of central analytical
laboratory & data analysis management service.

Progress: 82/01 to 82/12. Funds made
available by the North Central Region of the
State Agricultural Experiment Station (NC-141)
and the U.S. Department of Agricultural CSRS
are combined to support the coordination, data
management and publications for the
NC-141-sponsored program in atmospheric
deposition referred to as the National
Atmospheric Deposition Program (NADP). This
support has been primarily directed to the
establishment and coordination of a national
atmospheric deposition monitoring network.
Additional support has been obtained from other
Federal agencies including BLM, EPA, USGS, USFS
and NOAA, and a number of sites are supported
by state agencies and private corporations.
Since the beginning of the program in 1978,
this monitoring network has expanded to 108
operating sites across the country, including
Alaska and American Samoa. In 1983, NADP will
become the core of the National Trends Network
(NTN) which is being established under the
mandated National Acid Precipitation Assessment
Plan, with the addition of approximately 40
monitoring sites anticipated by 1984. Data
published by the program now includes eight
volumes covering data from July of 1978 through
December of 1980. In addition, the monitoring
data is available on computer tape either from
the Natural Resource Ecology Laboratory,
Colorado State University, or from the

04.008* CRIS0089822
CHEMISTRY OF ATMOSPHERIC DEPOSITION AND EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS

GIBSON J H; Natural Resource Ecology Lab;
Colorado State University, Fort Collins,
COLORADO 80523.
Proj. No.: C0L00223 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize
biologically important geographical and
temporal trends in the chemical climate of
North America. To assess the effects of
atmospheric deposition on the following: a) the
productivity of agricultural crops, forest
trees, rangelands, wetlands, and soils; b) the
health and productivity of domestic food
animals, wildlife, and fish; c) the chemical
composition of surface and ground waters; and
d) atmospheric visibility and the corrosion of
metals, masonry.

Approach: Provide coordination to further
develop and maintain the National Atmospheric
Deposition Program (NADP) chemical deposition
network as well as the NAPAP National Trends
Network (NTN).

Progress: 83/01 to 83/12. This project
furnished administrative support for research
carried on under the IR-7 interregional
research project goals stated above.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

04.009* CRIS0100004
ATMOSPHERIC DEPOSITION IN NATURAL ECOSYSTEMS OF
THE WESTERN UNITED STATES

FOX D G; Rocky Mountain Forest and Range
Experiment Station; Colorado State University,
Fort Collins, **COLORADO 80523.**
Proj. No.: RM-2153 Project Type: INHOUSE
Agency ID: FS Period: 01 OCT 84 to 30 SEP 89

Objectives: Create the basic knowledge needed
to determine aquatic and terrestrial ecosystem
effects resulting from specifically identified
air pollution sources.

Approach: The research is sequentially
structured to provide (1) protocols for
quantifying physical and chemical environmental
factors that influence aquatic and terrestrial
ecosystems, (2) a better understanding of
atmospheric delivery and ecosystem reception of
air pollutants, and (3) knowledge of the

biological effects caused by air pollutants introduced into ecosystems.

04.010* CRIS0045287
**EFFECT OF ENVIRONMENTAL AND AGRICULTURAL
 MANAGEMENT ON DENITRIFICATION AND SOIL/AIR
 N(2)O EXCHANGE**

MOSIER A R; HUTCHINSON G L; Integrated Row
 Crop Mgmt Syst Southern Piedmont Conserva Lab;
 USDA Agricultural Research Service, Fort
 Collins, COLORADO 80521.
 Proj. No.: 5402-20780-011-00D

Project Type: INHOUSE
 Agency ID: ARS Period: 02 MAY 79 to 02 MAY 84

Objectives: Evaluate in field and laboratory studies the key physical, chemical and biological phenomena which influence denitrification as it relates to nitrogen fertilizer use efficiency and the aerodynamic exchange of N(2)O between soil and the atmosphere.

Approach: A soil cover method and micrometeorological techniques will be employed to measure N(2)O flux from field soils. Field sites will be selected where comprehensive studies can be conducted to determine what conditions promote denitrification and N(2)O release from or absorption by the soil. At these sites the effect on vertical N(2)O exchange of environmental variables such as season, temperature, soil type and agricultural management factors such as crop, fertilization and irrigation will be considered. Flux measurements will be made frequently throughout the cropping season as each management step is taken. Laboratory studies will be conducted to relate field observations to denitrification theory and to determine the relationship between N(2)O production and total denitrification.

Progress: 83/01 to 83/12. Field N measurements of N(2) and N(2)O emissions from N-fertilized cropped fields and a native shortgrass prairie have indicated that in both systems little N loss occurred from denitrification. Data collected in 1983 tend to confirm these observations. A model which utilizes soil water, nitrate, ammonium and temperature data was developed to simulate N(2)O evolution from the shortgrass prairie. The model permits estimation of the individual contribution of nitrification and denitrification to N(2)O evolution. Acetylene, commonly used in denitrification work to block N(2)O reduction to N(2), was shown in laboratory studies to accelerate nitrate reduction. Acetylene was not directly utilized as a carbon source but the compound increased soil carbon metabolism thereby increasing the rate of denitrification.

Publications: 83/01 to 83/12

MOSIER, A.R., PARTON, W.J. and HUTCHINSON, G.L. 1983. Modelling nitrous oxide evolution from cropped and native soils. In R. Hallberg (ed.) Environmental

Biogeochemistry Ecol. Bull. (Stockholm) 35:2129-2141.

HAIDER, K., MOSIER, A.R., and HEINEMEYER, O. 1983. Side effects of acetylene on the conversion of nitrate in soil. Z. Pflanzenernahr. Rodenk. 146:222-233.

HAIDER, K., MOSIER, A.R., and HEINEMEYER, O. 1983. Side effects of acetylene on denitrification in soil. Agronomy Abstr. p. 159.

MOSIER, A.R. and PARTON, W.J. 1983. Denitrification in a shortgrass prairie: Modelling approach. 6th Int. Symp. on Environ. Biogeochem. p. 65. "Abstract"

04.011* CRIS0046570
**REDOX POTENTIAL AND
 NITRIFICATION-DENITRIFICATION REACTIONS IN SOIL**

GUENZI W D; Southern Piedmont Conservation Lab; USDA Agricultural Research Service, Fort Collins, COLORADO 80521.
 Proj. No.: 5402-20780-015-00D

Project Type: INHOUSE
 Agency ID: ARS Period: 30 SEP 80 to 30 NOV 85

Objectives: Determine the rate of denitrification in soil as a function of redox potential. Determine effects of redox potential, pH and soil properties on reactions of amino sugars and identify gaseous nitrogen products.

Approach: Laboratory studies will involve a close examination of the many interacting factors involved in the formation and reduction of N(2)O and the reaction of amino sugars and associated compounds with mineral nitrogen sources. The main emphasis will be placed on the effect of Eh and pH on reaction rates and pathways and compound stability in the nitrification-denitrification sequence. Redox systems will be designed to control Eh and pH at any desired value and will incorporate either a flow through or sealed technique for gas introduction and analysis. When appropriate, N labeled compounds will be used. Available detection equipment includes a mass spectrometer (MS), gas chromatograph (GC) with an electron capture detector, and GC-MS.

Progress: 83/01 to 83/12. Redox potentials and soil temperatures were measured at several depths in a barley field in northeastern Colorado. During the entire growing season, the mean redox potentials at any depth were not low enough to expect the denitrification of nitrate to nitrous oxide, although a very few individual readings were in the low 300 mV (Eh) range. The majority of emitted N(2)O was detected after a heavy rain and snow storm in May and an irrigation in July. Most of the N(2)O loss probably resulted from the nitrification pathway. Rates of N(2)O production or utilization in controlled redox soil slurries showed that not only was redox potential an important factor in evaluating the process, but small amounts of oxygen, NO(3), and NO(2) also had a profound influence on rate reaction and the type of transformation.

Publications: 83/01 to 83/12

BEARD, W.E. and GUENZI, W.D. 1983. Volatile sulfur compounds from a redox-controlled-cattle-manure slurry. J. Environ. Qual. 12:113-116.

04.012

CRIS0046521

FOREST METEOROLOGY AND AIR QUALITY

FOX D G; USDA Forest Service, Ft Collins, COLORADO 80521.
 Proj. No.: RM-2110 Project Type: INHOUSE
 Agency ID: FS Period: 13 AUG 80 to 03 OCT 84

Objectives: Develop methodologies that define and allow simulation of relationships between meteorological processes and forest and rangelands and encourage the incorporation of this information into land management planning activities. Current specific activities include outlining strategies for the management of air as a renewable natural resource and improving planning for the managed use of fire.

Approach: Through meteorological research, models and other tools will be developed to provide meteorological inputs into fire behavior and fire planning models applied to mountainous terrain in areas distant from weather stations. In addition, a decision process incorporating available and refined models of probable air pollutant movement, deposition and consequences in mountainous forests will be developed to aid Federal Land Managers in their responsibilities for reviewing PSD permit affecting Class I areas.

Progress: 80/08 to 84/09. A unique mountain climatology data base has been developed over four years with one-per-hour observations of meteorological variables on four different aspects and at three different elevations on Mount San Antonio, NM. Numerous observations of wind flows around the mountain have yielded information about the relationship between wind patterns and atmospheric stability. These data have established the validity of statistical models of mountain meteorology. Studies on the usefulness of meteorological information have developed analytical measures of the need for and location of meteorological monitoring. A system of computer models has been developed to aid air resource management decisionmaking. The Topographic Air Pollution Analysis System (TAPAS) includes topography data, two-dimensional and three-dimensional wind simulation models, dispersion models, and visibility impact assessment models. Also, TAPAS modules allow computer generated graphics map overlays (any map scale) of the model results. Utility of the system for operational decisionmaking has been demonstrated in the Bureau of Land Management and the Forest Service. Issues of model validity have been addressed culminating in work aimed at quantifying uncertainty in air quality model predictions. Growing recognition of the nondeterministic nature of the air quality modeling problem has led to better regulatory use of these tools.

Publications: 80/08 to 84/09

FOX, D.G. 1984. Uncertainty in air quality modeling. Bull. Amer. Meteorol. Soc. 65(1):27-36.
 FURMAN, R.W., HAINES, D.A., and MILLER, D.R. 1984. Meteorology and climatology. In: Handb. of For., K.F. Wenger, editor. John Wiley & Sons, Inc. New York. 3:97-141.
 MURPHY, D.J., BUCHAN, R.M. and FOX, D.G. 1984. Ambient total suspended particulate matter and benzo(a)pyrene concentrations from residential wood combustion in a mountain resor community. Amer. Ind. Hyg. Assoc. J.
 RUNNING, S.W. 1984. Documentation and preliminary validation of H2OTRANS and DAYTRANS, two models for predicting transpiration and water stress in western coniferous forests. USDA Forest Service Res. Pap. RM-252, 45p.
 FOX, D.G. 1983. Part A. U.S. experience with air quality modelling. p. 4-156. In: Procs. of Air Quality Modelling Science and Regulation Workshop. Melbourne, Australia, August 17-18, 1983.

04.013

CRIS0076782

CHANGE IN AIR POLLUTION AND NOISE POLLUTION AFTER THE INTRODUCTION OF PLANT MATERIALS: PHASE III

DILL N H; HELMY E M; Agri & Natural Resources; Delaware State Coll, Dover, DELAWARE 19901.
 Proj. No.: DELX-0006-79-2 Project Type: 1890/T
 Agency ID: CSRS Period: 01 OCT 78 to 30 SEP 84

Objectives: Determine the value of plant materials, ground surfaces, landforms, and barriers in reducing the levels of localized noise pollution. Determine the value of plant materials, ground surfaces, landforms, and barriers in reducing the levels of localized air pollution. Coordinate the use of plant materials, ground surfaces, landforms, and barriers to reduce air and noise pollution with these other desirable goals: Improvement of microclimate conditions for human comfort, esthetic enhancement of landscaped environment, provision of habitats for wildlife species compatible with high density human settlement patterns. Provide practical recommendations and guidelines for design of landscape modifications to reduce noise and air pollution.

Approach: See item No. 24.

Progress: 83/01 to 83/12. Comparative studies continue on attenuation effects of three species of 10-year-old pines: Loblolly Pine (Pinus taeda), White Pine (Pinus strobus), and Scotch Pine (Pinus sylvestris). In general, in the past mode, our results reflect the following characteristics for all species: (1) below 100 feet excess attenuation is not significant (2-4dBA), (2) between 100 and 200 feet excess attenuation increases monotonically to about 8-12dBA, (3) Scotch pine gives, on the average, better sound absorption than other white or loblolly pine. Plans to repeat this study after an interval of 8 years are being made (pine stands will be 18 years old). A

stand of deciduous shrubs and a stand of deciduous trees has been studied before and after removal of shrubs in both stands since 1978. Data are gathered in late winter (without leaves and mid-summer (with leaves). Analysis of data are yielding effects of removing shrubs (true insertion loss), attenuation effects of shrubs without leaves, and attenuation effects of regrowth of shrubs at 1-4 years after their removal. In general, a newly deshrubed surface attenuates better than a grassed surface. Insertion loss peaks around 75 ft and decreases in the 100-200 ft distances. Insertion loss also increases again in the 300-400 ft. distances. All studies use pink noise generated at a distance of 30 ft from the 0 ft reference point.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

04.014* CRIS0048807
**ECONOMIC IMPACTS OF ENERGY USE AND DEVELOPMENT
ON AGRICULTURE AND NATURAL RESOURCES**

ANDERSON W D; GREEN J W; USDA Economic Research Service, Washington, DISTRICT OF COLUMBIA 20250.
Proj. No.: NRED-LUC&D-4727

Project Type: INHOUSE
Agency ID: ERS Period: 01 JAN 76 to 30 DEC 83

Objectives: Estimate economic and locational impacts of coal mining, transportation, and utilization upon agriculture, land, water, air, and natural resource systems.

Approach: Project levels and locational impacts of coal development for the United States. Assess the impact of the 1990 base case projection on agriculture, and on land, water, and air resources. Provide special analyses to the Universities Research Group on Energy (URGE) (funded by EPA) to help assess alternative strategies for reducing damage from coal development, especially from coal-related pollution.

Progress: 82/10 to 83/09. A draft report was prepared on the impacts of energy development on rural resources. The principal investigator was assigned to EPA for FY 83 to complete specific data and modeling assignments for that agency.

Publications: 82/10 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

04.015 CRIS0074477
**CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND
EFFECTS ON LAND AND SURFACE WATERS**

MARTSDLF J D; Fruit Crops; University of Florida, Gainesville, FLORIDA 32611.
Proj. No.: FLA-FRC-01880 Project Type: HATCH
Agency ID: CSRS Period: 01 DCT 77 to 30 SEP 83

Objectives: Determining the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to the

total atmospheric deposition in various states and regions in the United States. Investigating the transport and transformations of atmospheric constituents.

Approach: IFAS School of Forest Resources and Conservation will be collecting wet and dry deposition. Associated daily climatological parameters, including wind direction, wind speed, air temp, dew point and radiation at 50 stations throughout Florida will be reduced and stored on magnetic tape and discs for random access and analysis. Various formats and accessibility to these data will be evaluated.

Progress: 82/01 to 82/12. Dr. Kenneth Portier has continued to refine access to HISARS (Hydrologic Information Storage and Retrieval System) which resides on a disc pack in the Northeast Regional Data Center assigned to the Climatology Laboratory of the Fruit Crops Department. On 18 June, both HISARS and SFFS (Satellite Frost Forecast System) were demonstrated to a Climatological User's Conference organized by the Florida State Climatologist, Dr. Charles Jordan, and held in the Meteorology Department of the Florida State University in Tallahassee. Discussions regarding this exchange of weather data between these systems and a computerized retrieval system under development at FSU led to the exchange of port protocols and accounts by the three cooperators. A regional project in Agricultural Climatology, S-173, has been organized during the year and progress toward its goals are reported separately under that project but effect the rainfall climatology of this project.

Publications: 82/01 to 82/12
NO PUBLICATIONS REPORTED THIS PERIOD.

04.016 CRIS0046519
FORESTRY WEATHER DATA SYSTEMS

PAUL J T; HAUCK C A; Southern Forest Fire Lab; USDA Forest Service, Macon, GEORGIA 31208.
Proj. No.: SE-2112 Project Type: INHOUSE
Agency ID: FS Period: 15 AUG 80 to 15 AUG 85

Objectives: Provide forest managers with access to decision-aiding systems based on current weather data, localized interpreted for forestry practices and develop techniques for accessing and controlling smoke impacts.

Approach: Develop a near real-time localized weather data base using interpolation/site correction techniques. Use 1 above as input to user decision models. Determine the influence of stability on fire, develop and test a low-level stability index. Using satellite, digital radar data and surface observations, develop a model which will estimate rainfall between stations. Develop site specific weighting function as an adjustment for interpolation. Develop management models for smoke management using the weather data base and current knowledge of smoke.

Progress: 82/10 to 83/09. Greater fire spread during unstable weather conditions may be accounted for by modifying manning class by one or more categories, depending on the value of the Turner Stability Class used in smoke management, according to a preliminary test. The Forestry Weather Data System (FWIS) is being implemented on a Georgia Forestry Commission computer and on interim basis until FLIPS becomes available. FWDS will be used to make forestry weather duties and forecasts available to federal, state, and industrial forestry users, as well as a base to drive various user decision model such as fire weather and smoke management. A manuscript describing a dispersion under for multiple fire smoke management has been submitted to the Journal of Applied Meteorology. The first version of a FORTRAN computer program for protecting visibility in the Olympic National Park and adjacent smoke sensitive areas has been implemented; an improved version to incorporate complex wind flow patterns and real time weather data is under development.

Publications: 82/10 to 83/09

- LAVDAS, L.G. 1983. Rural Dispersion Climatology of the Contiguous United States In: 76 Annual Meeting of the Air Pollut. Central Assoc. 1983, June 19-24, Atlanta, Ga.
LAVDAS, L.G. 1983. A Sampling of Present and Projected Smoke Mangement Products. In: 7th Conf. of Fire & Forest Meteorol. Soc. & the Soc. of American Foresters; April 25-27. Ft. Collins, CO; Am. Meteorol. Soc., Boston, MA; 1983.

04.017* CRIS0089884
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

MCFEE W W; PAW-U K T; Agronomy; Purdue University, West Lafayette, **INDIANA** 47907.
Proj. No.: IND050045A Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, rangelands, wetlands and soils.

Approach: We will continue to operate one site at the Agronomy Farm to measure atmospheric deposition and plan to initiate a site in southern Indiana. We will develop and test models of the short and intermediate range transport of atmospheric, point source pollutants. Laboratory experiments on the effects of acidic deposition on the chemical and physical properties of soil will be used to examine the movement of metal in response to acidity and to evaluate soil sensitivity rating systems.

Progress: 84/01 to 84/12. Data from 2 years of studying the stmospheric deposition of acidic and nutrient materials in the

precipitation at the Purdue Agronomy Farm were summarized an prepared for publication. The mean volume-weighted pH based on laboratory analyses is 4.36. The unweighted mean weekly sample pH based on measurements taken before shipment of the samples if 4.15. There is a tendency for sulfate and H ion concentration to be higher in the growing season. The mean annual S and N deposition in the precipitation based on two year's data is 8.4 kg/ha and 6.2 kg/ha respectively. Sampling and analysis of the precipitation of the Southwest Purdue Agricultural Center at Vincennes was begun in August, 1984 to support the studies of air pollution effects on melons being conducted there.

Publications: 84/01 to 84/12

- MCFEE, W.W., ADAMS, F., CRONAN, C.S., FIRESTONE, M.K., FOY, C.D., HARTER, R.D. and JOHNSON, D.W. 1984. The acidic deposition phenomenon and its effects: Chapter E2, Effects on soil systems. EPA-600/8-83-016 F. pp. 2-1 through 2-57.

04.018 CRIS0087502
BOUNDARY LAYER PHENOMENA & ACIDIC PRECIPITATION

PAW-U K T; Agronomy; Purdue University, West Lafayette, **INDIANA** 47907.
Proj. No.: IND050079 Project Type: HATCH
Agency ID: CSRS Period: 01 JUN 82 to 01 MAY 84

Objectives: To analyze and identify the importance of air flow in the vicinity of vegetation, and its interaction with the air flow in the atmospheric boundary layer. To analyze and identify the nature of the interaction between biota and the atmospheric boundary layer, and to identify key variables in the interaction.

Approach: Theoretical, field, and laboratory research will be conducted to determine the patterns and turbulent nature of clean or particle-laden air flow in the vicinity of vegetative elements. The patterns will be analyzed in terms of interactions between the biota and atmosphere; the transport of such material as sulfur compounds and their effect on acidic precipitation will be of special interest.

Progress: 83/01 to 83/12. The estimation of leaf diffusive resistances as a function of temperatures of coated and uncoated leaves was modeled; it was found estimations with the energy budget method were as accurate as porometrically derived values. Theoretical work was also done on the occurrence of equal leaf and air temperatures. The nature of pollen trajectories in the vicinity of ovulate cones was examined with the aid of videotape analysis, and it was determined that many factors increase net deposition of pollen grains on the ovulate cones. It was determined, however, that the von Karman vortex formation behind ovulate cones was probably not a significant phenomenon in terms of evolutionary pressure. Acidic precipitation studies continued at Purdue. Very low pH values were measured for some precipitation (less than

3.5), but no values higher than 5.6 were reported. Theoretical work showed that under certain conditions, a single power plant of the 60 mW size could cause significant acidic precipitation from over 100 to 300 km downwind. The model used was not valid for greater distances, although it is possible the contribution would also be significant at those locations.

Publications: 83/01 to 83/12

- PAW U, K. T. 1984. A theoretical basis for the leaf equivalence point temperature. Accepted by Agricultural Meteorology.
- ANDRESEN, J. and PAW U, K. T. 1984. Modeling of SO₂ emissions and acidic precipitation at mesoscale distances. Accepted by Electric Utilities Research Conference, Chicago, 1984.
- NIKLAS, K. J. and PAW U, K. T. 1983. Conifer ovulate cone morphology: implications on pollen impact patterns. Amer. J. Botany 70:568-577.
- PAW U, K. T. 1983. Rebound of particles from natural surfaces. J. Colloid Interface Science. 93:442-452.
- PAW U, K. T. 1983. A universal model for entrainment processes. Accepted by Proceedings, 4th Conference on Precipitation Scavenging Dry Deposition and Resuspension, 29 Nov.-Dec. 1982. (Refereed proceedings).

04.019*

CRISO074636

CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION & EFFECTS ON AGRICULTURAL & FORESTED LAND & SURFACE WATER

TABATABAI M A; Agronomy; Iowa State University, Ames, IOWA 50011.
Proj. No.: IOWO2276 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish an atmospheric deposition network. Determine the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to total deposition. Develop optimum procedures for collecting precipitation and dry particulate matter. Determine the stability of certain constituents of precipitation during collection, transport and storage prior to analysis. Investigate the transport and transformations of atmospheric constituents.

Approach: A network of precipitation collection sites will be established in the U.S. one of these sites will be in Central Iowa. Samples of precipitation and dry particulate matter will be collected at each site. The samples will be analyzed for SO₄(4) -, NO₃(3) -, PO₄(4) -, Cl -, NH₄(4) -, K -, Na -, Ca +, Mg +, pH, total and free acidity or alkalinity, and electrical conductivity. As the program develops, the analyses for heavy metals will be included.

Progress: 81/01 to 81/12. Rainfall collectors and measuring gauges were installed in 1978 at seven sites in Iowa. The sites are in Ames, the Agronomy farm in Boone County, Atlantic, Fairfax, Sigourney, Storm Lake, and Tripoli. Precipitation samples were collected

on an event basis each year from May through November and analyzed for pH, conductivity, F -, C -, NH₄⁺/4, NO₃⁻/3, SO₄²⁻/4, PO₄³⁻/4, K M Na -, Ca -, and Mg -. With exception of a few samples each year, the pH of the precipitation samples analyzed from the seven sites ranged from 5 to greater than or equal to 7, with the majority of the samples having pH value near 6. The most recent results (for 1983) showed that the pH values ranged from 4.1 of one sample collected at the Agronomy farm 7.4 of a sample from Storm Lake. The means and standard deviations of the pH values at the seven sites were: Ames, 5.9 +/- 0.5; Agronomy farm, 5.9 +/- 0.7; Atlantic, 6.7 +/- 0.2; Fairfax, 6.2 +/- 0.7; Sigourney, 6.7 +/- 0.3; Storm Lake, 6.2 +/- 0.5; Tripoli, 6.5 +/- 0.3. Expressed in $\mu\text{g/ml}$, the mean values of NO₃(3)-N and SO₄(4)-S, respectively, were 0.5 and 1.0 (Ames), 0.4 and 0.9 (Agronomy farm), 0.7 and 1.4 (Atlantic), 0.8 and 2.3 (Fairfax), 1.4 and 2.5 (Sigourney), 0.7 and 1.0 (Storm Lake), and 0.5 and 1.3 (Tripoli). In general, the means of NH₄⁺/4-N concentrations were equal or slightly greater than those of NO₃⁻/3-N.

Publications: 81/01 to 81/12

- TABATABAI, M.A. 1982. Nutrient deposition by precipitation. Proceedings of a Public Conference. 120-140. Carroll University, University Heights, Cleveland, Ohio.
- TABATABAI, M.A. 1983. Atmospheric deposition of nutrients and pesticides. In F.W. Schaller and G.W. Bailey (eds.). Proceedings of the National Conference on Agricultural Management and Water Quality, pp. 92-108.
- SALEEM, H.B. 1983. Effect of pH on nitrogen mineralization and nitrification in soils. M.S. Thesis, Iowa State University, Ames. 110 p.
- TABATABAI, M.A. 1984. Effect of acid rain on soils. CRC Crit. Rev. Environ. Cont. (In press).
- LINZON, S.N., and TABATABAI, M.A. 1984. Soil-air pollutant interaction. In S.V. Krupa and A.H. Legge (eds.). Proceedings of the International Conference on Air Pollutants and Their Effects on Terrestrial Ecosystem. Wiley

04.020

CRISO081767

FURNACE TESTING OF THE COMBUSTION CHARACTERISTICS OF AGRICULTURAL DUSTS

LESTER T W; MERKLIN J F; Nuclear Engineering; Kansas State University, Manhattan, KANSAS 66506.

Proj. No.: KAN-05-827

Project Type: SPECIAL GRANT
Agency ID: CSRS Period: 01 JUL 80 to 31 DEC 82

Objectives: A two year experimental program is undertaken to determine the firing and pollution formation characteristics of the suspension firing of agricultural dusts. The program will provide information on what conditions of suspension firing will minimize the potentially large nitric oxides formation from easily evolved nitrogen bound into the dusts. Additionally, the co-firing with coal will determine to what extent ash from

agricultural fuels can reduce SO₂ emissions from high sulfur coal.

Approach: A scale model furnace, fully instrumented and capable of simulating the conditions in the primary flame zone of suspension fired furnaces, will be used as the test facility.

Progress: 80/07 to 82/12. Tests to determine the levels of nitrogen oxide emissions and the success of combustion modifications in their control from the combustion of agricultural and forest residues have been concluded. It was observed that the nitrogen oxide emissions from the forest residues were comparable to those obtained from the firing of natural gas because of the low inherent fuel-bound nitrogen content of those fuels. On the other hand, the nitrogen oxide emissions from the firing of wheat straw and corn stover were comparable to those generated from the firing of pulverized coals with equivalent nitrogen contents (1-2%). Consequently, the uncontrolled firing of these residue fuels in small utility and industrial boilers is apt to cause emissions exceeding regulated levels for units of greater than 250,000 lbs./steam-hr. The firing of these biomass fuels with various pulverized coals resulted in nitrogen oxide emissions significantly greater than from either the coal or the biomass fuel by itself. This increase, which is up to 20%, may be due to the large amounts of readily evolved oxygen from the biomass that reacts with the evolved nitrogen in the early stages of the flame.

Publications: 80/07 to 82/12

ZAMANI, H.S. 1983. Nitrogen oxide emissions from the combustion of agricultural residue/pulverized coal mixtures. M.S. Thesis, Kansas State University, Manhattan.

RDENIGK, R.A. 1983. Ammonia and hydrogen cyanide production during the combustion of agricultural residue/pulverized coal mixtures. M.S. Thesis, Kansas State University, Manhattan.

LESTER, T.W., MERKLIN, J.F., ZAMANI, H. and RDENIGK, R.A. 1983. NO(x) formation from the combustion of agricultural and forest residues. The Combustion Institute/Central States Section 1983 Spring Meeting. (Accept. for pub.).

04.021 CRIS0088960
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

FEAGLEY S E; Agronomy; Louisiana State University, Baton Rouge, **LOUISIANA** 70803.
 Proj. No.: LAB02307 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the chemical composition of surface and ground waters.

Approach: These objectives will be achieved by further developing and maintaining the NC-141/NADP atmospheric chemical deposition and related local networks. Estimates of atmospheric sources of nutrients for growth of agricultural crops and forest trees will be taken. Contribution of atmospheric sulfur to growth of cultivated and non-cultivated crops. Foliar uptake of nutrient and toxic metals by forest trees and orchard, field, forage and vegetable crops. Identification of regions that are sensitive and soil factors contributing to sensitivity to acid precipitation. Influence of precipitation chemistry on mineral weathering, colloid chemistry, clay development, and suspension potential of soils. Long-term and short-term changes in atmospheric deposition and mobilization of heavy metals.

Progress: 84/01 to 84/12. The total amount of rainfall at Homer, New Iberia and Franklinton through 12/19/84 was 54.93, 60.36 and 56.12 inches, respectively. The range in pH for each site respectively was 4.95 to 4.07, 5.56 to 4.20 and 5.66 to 4.01. The range in EC was 25.7 to 3.9, 40.0 to 4.2 and 40.0 to 8.5 mu S/cm.(+) Other parameters being monitored are ND(3), PO(4), SO(4), Cl, Ca, Mg, K, Na and NH(4). Four ponds are being monitored weekly by taking surface samples. All parameters mentioned above are being done on the samples as well as temperature. A lake sampler is being tested to sample the lake from the shore at various depths.

Publications: 84/01 to 84/12

FEAGLEY, S.E. and CREMERS, R.B. 1984. Acid rain and its accumulation: A problem in Louisiana? La. Agric. 27:4, 5 and 24.

04.022 CRIS0086840
ATMOSPHERIC DEPOSITION OF ACID RAIN AND MINERAL ELEMENTS IN LOUISIANA

JONES J P; FEAGLEY S E; Agronomy; Louisiana State University, Baton Rouge, **LOUISIANA** 70803.

Proj. No.: LAB02249 Project Type: HATCH
 Agency ID: CSRS Period: 01 MAR 82 to 04 JAN 83

Objectives: Establish atmospheric deposition collection sites for wet and dry precipitation in selected areas and provide appropriate data in cooperation with the National Atmospheric Deposition Program (NC-141).

Approach: Monitor precipitation from the atmosphere in Louisiana to include: pH, wet and dry deposition of sulfur, nitrogen and heavy metals. Determine the effect of acid precipitation and the deposition of sulfur and heavy metals on agricultural crops and livestock.

Progress: 82/03 to 83/01. Project H2249 on NC0141 is being terminated and replaced by H2307 on IR-7 project. Three NADP sites were established in Louisiana. These were located at Homer, Iberia and Franklinton. The Homer and Iberia sites were put into operation on November 16, 1982. Franklinton will be started at a later date because of electrical

difficulties. The pH values ranged from 4.78 to 5.18 at Homer and 4.50 to 5.76 at Iberia. The precipitation weighted averages from 11/16/82 to 1/4/83 were 5.01 at Homer and 5.44 at Iberia. The E.C. values ranged from 1.2 to 13.5 umhos./cm. at Homer and 3.8 to 15.2 umhos./cm. at Iberia. The precipitation weighted averages were 8.0 and 5.5 umhos./cm. at Homer and Iberia, respectively.

Publications: 82/03 to 83/01

NO PUBLICATIONS REPORTED THIS PERIOD.

04.023* CRIS0089304
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, & MATERIALS

NORTON S A; Geology; University of Maine, Orono, MAINE 04469.

Proj. No.: ME08904 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: (To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America). Specifically, to operate one (1) NADP precipitation collection station at Greenville, Maine. (To assess the effects of atmospheric deposition on the following: a) the productivity of forest trees, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife and fish, and c) the chemical composition of surface and ground waters.

Approach: Specific Projects under investigation in FY 83 at UMD include (as listed in the proposal), B1, 2, 6; C1; D2; E1, 2; G1, 2, 4; H1, 2, 3; I1, 2.

Progress: 83/10 to 84/09. The precipitation collection station has been in operation at Greenville, Maine for this past year which is part of the National Atmospheric Deposition Program. A cooperative agreement exists with Mr. Llew Wortman of the Moosehead Sanitary District facility at Greenville, Maine to operate the site. Mr. Wortman has carried out the sample collections, field measurements, and the shipping of samples to the analytical laboratory in Urbana, Illinois. Mr. Wortman and Dr. Fernandez implemented some improvements for the Greenville station this year which included (a) purchase of a new pH meter, (b) purchase of a new conductivity meter, and (c) relocation of the collector to improve the integrity of samples collected. The Greenville Station is now officially recognized as a site in both NADP and the National Trends Network. Dr. Fernandez participated in the annual technical committee meetings in Asheville, North Carolina and was elected vice chairman of the IR-7 Forestry Effects working group.

Publications: 83/10 to 84/09

FERNANDEZ, I.U. Acid Deposition and Forest Soils: Potential Impacts and Sensitivity. In Adams, Donald D. and Walter Page (eds.). Acid Deposition Environmental, Economic, and Policy Issues. Plenum Press, NY (in press) BERNSTEN, C.M., CORLISS, J.F.,

FERNANDEZ, I.U., JOHNSON, D.W., JONES, H.C., III, SMITH, W.H. and LYONS, J.R. 1984. Report of the SAF Task Force on the Effects of Acidic Deposition on Forest Ecosystems. Society of American Foresters. FERNANDEZ, I.U. and CZAPOWSKYJ, M. 1984. Forest Floor Heavy Metals Levels in Low Elevation Commercial Spruce-Fir Stands in Maine. Agronomy Abstracts. Madison, Wisconsin p. 258

04.024 CRIS0089415
CHEMISTRY OF ATMOSPHERIC DEPOSITION-EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS & MATERIALS

BRINSFIELD R B; Wye Res & Education Center; University of Maryland, Queenstown, MARYLAND 21658.

Proj. No.: MD-R-072 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America.

Approach: The primary goal of the Network Monitoring Program will be to provide atmospheric deposition information of maximum value for the Effects Research Program. A total of about 125 sites will eventually be required to provide accurate and representative information concerning geographical as well as seasonal, yearly, and other temporal variations in the chemistry of precipitation and dry deposition regions of the United States.

Progress: 84/01 to 84/12. During 1984, weekly composite wet deposition samples were collected. Samples were analyzed for pH and conductivity at the Wye Research and Education Center (WREC). Dry deposition samples were collected quarterly. Samples were sent to the Illinois Water Quality Laboratory in prepackaged containers for the following chemical analyses: Ca, Mg, K, Na, NH(4), NO(3), Cl, SO(4), and PO(4). Quarterly reports were forwarded to WREC. The data are entered on a computer file for a permanent record. Annual pollutant loads for nitrogen, phosphorus, and sulfur from June 1983 to June 1984 are 8.37, <1.0, and 9.24 kg/ha, respectively. For the same time period, the average pH of the rain was 4.44 with a minimum of 3.62 and a maximum of 5.15. The database has been made available to other scientists with interest either directly in acid rain or its effects on aquatic and terrestrial ecosystems.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

04.025* CRISO074631
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND
EFFECTS ON LAND AND SURFACE WATERS

HART J B; Forestry; Michigan State University,
 East Lansing, **MICHIGAN** 48824.
 Proj. No.: MICLO1282-H Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 28 DEC 84

Objectives: Establishing an Atmospheric Deposition Network to determine special & temporal trends in the supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter deposited in various regions of the United States. Organizing and coordinating research in the SAES, FS, and other research institutions & agencies on the effects of changes in atmospheric deposition on: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters; The health & productivity of domestic food animals, wildlife, and fish; and the corrosion of metals, painted surfaces, masonry, and other materials in machinery or structures.

Approach: Establishment of two monitoring sites in Michigan. Weekly analysis of collected precipitation & dry particulates. Use trends to find effects on forest growth & reproduction.

Progress: 83/01 to 83/09. Research activities were pursued in this project prior to initiation of Project IR-7. Two wet-dry deposition monitoring sites are maintained as part of the National Atmospheric Deposition Program network and National Trends Network: one at Kellogg Biological Station in southwest lower Michigan; and one at the University of Michigan Biological Station in north central lower peninsula Michigan. Precipitation acidity has ranged from extremes of 3.8 to 7.2 with a normal range of 4.2 to 5.7. Simulated acid precipitation of pH 2.5 and below adversely affected greenhouse germination and survival of jack pine. Foliar necrosis and stem lesions were produced on seedlings grown at pH 3.0 and below. Preliminary results indicate episodic simulated acid precipitation of pH 3.0 has no significant effect on survival, growth, or foliar appearance of one-year old jack pine seedlings or competing species of *Carex* sedge. Interpretation of the monitoring network results using information from previous research indicate that neither the extremes or normal acidity ranges are sufficient to preclude the germination and early development of *Pinus banksiana* on typic Udipsamment soils of the region.

Publications: 83/01 to 83/09
 MACDONALD, N.W. 1983. The effects of simulated acid precipitation on regeneration and soils in the Jack pine-Grayling sand ecosystem. M.S. Thesis. Michigan State University, E. Lansing, 189p.

04.026* CRISO091453
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS

HART J B; Forestry; Michigan State University,
 East Lansing, **MICHIGAN** 48824.
 Proj. No.: MICLO1447 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on a) productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife, and fish; c) the chemical composition of surface and ground waters; and d) atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Deposition sites will be instrumented and maintained in specific ecosystem strata occurring in Michigan according to IR-7/NADP protocol. Regional and network evaluation of monitoring data will be conducted. Effects of past, present and potential atmospheric deposition will be studied by vegetative, soil and hydrologic components. Statistically designed experiments and sample collections will be conducted on important components of individual ecosystems, and groups of systems, to test hypothesized effects and quantify relationship. These studies, where appropriate, will be conducted in cooperation with other states and regions. Biologically and economically feasible strategies for control and treatment of atmospheric deposition effects will be developed from these results.

Progress: 84/01 to 84/12. Two wet-dry deposition monitoring sites were maintained as part of the National Atmospheric Deposition Program network and National Trends Network: one at Kellogg Biological Station in southwest lower Michigan; and one at the University of Michigan Biological Station in north central lower peninsula Michigan. Precipitation acidity has ranged from extremes of 3.8 to 7.2 with a normal range of 4.2 to 5.7. Evaluation of the monitoring network results and recent research on *Pinus banksiana* regeneration indicate that neither the extremes or normal acidity ranges are sufficient to preclude the germination and early development of jack pine forests on typic Udipsamment soils of the region. Approximately 40% of Michigan soils have been determined to be sensitive or slightly sensitive using published criteria. Most are predominately forested soils. Current research is reevaluating the sensitivity of Michigan and Upper great lakes forested soils to atmospheric deposition and the long-term effects of nutrient depletions and acidification.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

04.027* CRIS0068955
**ACIDIC RAIN: REGIONAL RAIN CHEMISTRY & LONG
 RANGE TRANSPORTED VS. LOCAL SOURCE EMITTED
 POLLUTANTS**

KRUPA S V; Plant Pathology; University of
 Minnesota, St Paul, MINNESOTA 55108.
 Proj. No.: MIN-22-074 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 82 to 30 JUN 83

Objectives: To determine the major inorganic
 ion composition of individual rainfalls in
 Minnesota; to apply appropriate numerical
 analyses to predict the association of sulfate
 and nitrate with various cations, including
 hydrogen; to separate rainfalls preceded by
 long range pollutant transport (LRTAP) from
 those governed by local meteorological
 processes, through the use of reverse air
 parcel trajectory analyses; and to estimate
 from objective 3, the contributions of LRTAP
 vs. local processes to the nature of rainfall
 and its acidity.

Approach: Individual rainfalls will be
 collected during the summer at selected sites
 in Minnesota using an automatic, refrigerated,
 sequential, sampler. These samples will be
 analyzed for major anions and cations. The
 anions, SO²⁻(4) and NO³⁻(3) will be examined
 mathematically for their association with
 hydrogen (acidity) and other cations. Rainfalls
 with different values of pH and SO²⁻(4) and
 NO³⁻(3) concentrations will be related to daily
 reverse air parcel trajectories to separate
 LRTAP vs. local influences as they relate to
 sulfate and nitrate concentrations in the
 individual rains. Further, these processes will
 be related to NH⁺(4) in the rainfall.

Progress: 84/01 to 84/12. The impacts of a
 scrubbed plume from a coal-fired power plant on
 the terrestrial vegetation in the vicinity,
 were investigated over a period of 10
 consecutive summers. Ground level sulfur
 dioxide concentrations at eight isopleths were
 mostly below 26 ug/m³/hr and never exceeded 390
 ug/m³/hr. About 75% of the sulfate and nitrate
 in the rainfall was in a non-acid form, and was
 influenced by long range transport, as
 evidenced by back trajectory analysis.
 Vegetation in the vicinity of the source
 exhibited foliar sulfur accumulation due to the
 atmospheric inputs, for the first three years,
 after which it leveled off. The vegetation
 appeared to have compensated for the soil
 sulfur deficiency through atmospheric inputs.
 This was confirmed by using S and boron as
 tracers of the source plume. No trends in soil
 chemistry were found during the 10 year period.
 Farming practices appear to be a more important
 factor in this context. The atmospheric sulfur
 inputs did not result in crop productivity
 changes in soybean. On the other hand, the low
 sulfur dioxide inputs resulted in a reversal of
 the effects of ozone on soybean yield.

Publications: 84/01 to 84/12

KRUPA, S.V. 1984. Field exposure methodology
 for assessing the effects of photochemical
 oxidants on crops. Proc. Ann. Air Pollut.
 Control Assoc. San Francisco, CA. 84:104.
 2:1-13.

KRUPA, S.V. 1985. Impacts of scrubbed plume
 from a coal-fired power plant on
 terrestrial vegetation. Perspectives in
 Environmental Botany. (In press).

04.028* CRIS0078453
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
 ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
 MATERIALS**

KRUPA S V; Plant Pathology; University of
 Minnesota, St Paul, MINNESOTA 55108.
 Proj. No.: MIN-22-080 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize
 biologically important geographical and
 temporal trends in the chemical climate of
 North America. To assess the effects of
 atmospheric deposition on the following: a) the
 productivity of agricultural crops, forest
 trees, rangelands, wetland and soils.

Approach: This objective will be achieved by
 further developing and maintaining the
 NC-141/NADP atmospheric chemical deposition
 network and related local networks. The Program
 will determine spatial and temporal trends in
 the supply of beneficial nutrient elements and
 potentially injurious substances in both wet
 and dry deposition in various regions of the
 United States. The Program will also describe
 the atmospheric processes by which essential
 nutrients, strong acid and acidifying
 substances, toxic metals, and other beneficial
 and injurious substances are transferred from
 various man-made and natural sources through
 the atmospheric and are deposited on plant,
 animals, soils and surface waters. The work of
 this Network will be developed in parallel with
 the related Canadian Network for Sampling
 Precipitation (CANSAP).

Progress: 84/01 to 84/12. Chemical
 characteristics of aerosol and rain samples
 collected at five sites in Minnesota during the
 summer of 1982 were generally similar in regard
 to the relative proportions of major
 constituents. On a mass basis, sulfate was the
 predominant component in the fine particle (<2.5 μm)
 fraction. The concentrations of
 crustal materials in both the aerosol and the
 rain followed a gradient in which
 concentrations increased with proximity of the
 sampling site to the prairie. The
 concentrations of the crustal materials in the
 aerosols were correlated with their
 concentrations in subsequent rain, whereas
 concentrations of other constituents were not
 significantly correlated between aerosol and
 rain. Nitrates and crustal materials were
 removed more effectively by both wet and dry
 mechanisms than ammonium, sulfate and other
 constituents occurring predominantly in the
 fine fraction. The components in the aerosols
 were divided by factor analysis into: ammonium
 sulfates, crustal materials.

Publications: 84/01 to 84/12

GUIANG, S.F., KRUPA, S.V. and PRATT, G.C.
 1984. Measurement of S(IV) and organic
 anions in Minnesota rain. Atmos. Environ.

18:1677-1682.

PRATT, G.C. and KRUPA, S.V. 1985. Aerosol chemistry in Minnesota and Wisconsin and its relation to rain chemistry. Atmos. Environ. (In press).

04.029 CRIS0005009
RELATIONSHIPS BETWEEN CERTAIN AIR POLLUTANTS AND VARIOUS METEOROLOGICAL FACTORS

REISS N M; Meteorology and Physical Oceanography; Rutgers University, New Brunswick, NEW JERSEY 08903.
 Proj. No.: NJ13104 Project Type: HATCH
 Agency ID: CSRS Period: 08 NOV 82 to 30 SEP 85

Objectives: To apply a thorough meteorological analysis to two data sets that have recently been obtained: Measurements of various organic vapors that were made for two six-week periods during Summer 1981 and Winter 1982 at four locations in New Jersey; Analyses of benzo(a)pyrene concentrations at 40 locations in New Jersey obtained from weekly high-volume sampler observations.

Approach: Correlations will be computed between pollutant concentrations and the number of hours that the wind blew from each direction during the sampling period. For each pollutant sampled, results will be displayed as "correlation roses" in which the lengths of the "spokes" reflect the degree of correlation of the concentration of that pollutant with the particular wind direction. The effect on the correlations of various mixing height and emission rate assumptions will be tested.

Progress: 84/01 to 84/12. Work was continued on development of a model that simulates the dispersion, during rainfall events, of hydrogen chloride (HCl) that is emitted from stacks of resource recovery facilities (municipal solid waste incinerators). A number of such facilities are proposed for construction in the State of New Jersey. The earlier phase of this study indicated that much of the hydrogen chloride is washed out by the rain within a few tens of feet after the plume leaves the stack, but the model did not incorporate thermal effects that occur in the plume. During 1984, work progressed on two tasks that need to be accomplished in order that thermal effects may properly be taken into account. First, the equation accounting for dispersion of heat that is emitted from the stack is being coupled with the equations for dispersion and phase change of HCl, thereby defining the temperatures necessary for computation of HCl droplet sizes. Second, phase diagrams of HCl found in the literature in graphical form are being converted to systems of equations in order that they may be used with the numerical model. Although we have extracted some of this information for use in the earlier phase of the study, it had not been done for the high temperatures that we expect will be encountered in incinerator plumes.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

04.030 CRIS0097783
DISPERSION OF HYDROGEN CHLORIDE FROM MUNICIPAL SOLID WASTE INCINERATORS

REISS N M; Meteorology and Physical Oceanography; Rutgers University, New Brunswick, NEW JERSEY 08903.
 Proj. No.: NJ13401 Project Type: STATE
 Agency ID: SAES Period: 01 JAN 86 to 30 JUN 89

Objectives: To examine the behavior in the atmosphere of hydrogen chloride emissions from municipal solid waste incinerators. A model will be developed that incorporates the effects of plume dispersion, temperature, humidity, and precipitation washout.

Approach: Existing research that describes the behavior of hydrogen chloride under various conditions of temperature and humidity will be combined with a model that describes the hydrogen chloride concentration and the temperature and humidity environment in a municipal solid waste incinerator plume within about one kilometer of the point of emission. Washout by precipitation of gaseous hydrogen chloride or hydrogen chloride droplets with sizes computed by this technique will be simulated by a precipitation washout model obtained from the existing literature.

04.031 CRIS0079884
THE ECONOMICS OF AIR QUALITY AND ENERGY USE

MOUNT T D; CHAMPMAN L D; WHITE G B;
 Agricultural Economics; Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-121505 Project Type: HATCH
 Agency ID: CSRS Period: 21 SEP 84 to 30 SEP 87

Objectives: To develop new methods for assessing the economic consequences of improving air quality, particularly those relating to acid deposition. The initial focus will be on controlling sources of emissions from power plants in New York.

Approach: Over the past four years, Cornell has participated with University Research Group on Energy (URGE) in the development of an Advanced Utility Simulation Model (AUSM). The structure of the model includes all of the major functions of a utility system, and it incorporates both engineering and economic components. Since electric utilities account for roughly two thirds of the total emissions in the U.S., the model accounts for the major source of emissions causing acid deposition. Furthermore, since the model provides information about individual power plants, the spatial distribution of emissions can be analyzed, and the model can be used to link to long-range air transportation models to study the corresponding spatial distribution of deposition. The most important development will be to relate emissions from power plants to the

damage caused by acid deposition to forests, agricultural crops, etc.

Progress: 84/01 to 84/12. A study of regional variations in solar insulation, solar heating systems, tax credits, and conventional heating systems indicates that solar domestic hot water heating is competitive with electric hot water in two-thirds of the country, but only with natural gas in the Southwest and Hawaii. A review of current literature on air pollution concludes that several New York crops suffer damage at current ozone levels, that decline in forest growth is affecting New York, and that the role of acid deposition in these two problems remains unclear. A general equilibrium model of trade has been developed for evaluating alternative policies for resolving transfrontier pollution problems. This model determines prices, output levels and national income for each country, given a specified tariff or transfer policy. An application was made to the acid rain dispute between Canada and the U.S., but the quality of data was not good enough to provide reliable estimates of certain key parameters. Development of a utility simulation model for New York State continued, and an analysis was completed as part of the Draft Environmental Impact Statement on Sulfur Controls for the Department of Environmental Conservation.

Publications: 84/01 to 84/12

- HEINZE-FRY, G.R. The economics of home solar water heating. 1984. A.E. Res. 84-12. Cornell Univ., Ithaca, N.Y. 134 p.
 CDNSIDINE, T.J. and MDUNT, T.D. 1984. The use of linear logit models for dynamic input demand systems. The Review of Economics and Statistics, 66(3):434-443.
 CHAPMAN, D. and KOHUT, R. 1984. Ozone and acid deposition. In Energy industries in transition, Weyant, J. (ed.) 19 p. and A.E. Staff Paper No. 84-28. Cornell Univ., Ithaca, N.Y. 19 p.

04.032 CRIS0075990
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

KNAPP W W; Agronomy; Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-125436 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America.

Approach: Continue the operation of the wet/dry deposition sampling site near Aurora, N.Y. as part of the NADP national sampling network. All sampling equipment and procedures will be in accordance with specifications of the NADP Field Observer Instruction Manual. Data from NADP network sites will be used to develop annual and seasonal maps depicting desposition patterns of nutrient and other chemical elements supplied to natural vegetation, crops, and aquatic systems by precipitation.

Statistical methods applied to NADP precipitation chemistry data will be used to characterize natural dosage patterns of biologically important chemical substances in precipitation. Precipitation chemistry data will be analysed and correlated with meteorological and source emissions data in order to investigate the causes of observed spatial and temporal patterns atmospheric deposition.

Progress: 83/10 to 84/09. Weekly wet deposition samples and eight-weekly dry deposition samples have been collected and analysed from a site near Aurora, NY throughout the reporting period. An analysis of nutrient inputs provided to agricultural lands and crops by wet deposition has been completed. Based on 1978-1983 data, precipitation over the course of an average year in central New York State supplies to the crop and soils of the region the following approximate amounts of nutrient substances: nitrogen; 5.2 kg/ha, phosphorus; <0.1 kg/ha, potassium; 0.7 kg/ha, and sulfur; 12.4 kg/ha. The average annual input of hydrogen ions from precipitation amounts to about 0.6 kg/ha. The amounts of N, P and K provided by wet deposition are at most only a small fraction of the recommended nutrient requirements for the production of agricultural crops typical of the region. Requirements for additional amounts of lime, CaCD(3), to neutralize hydrogen ion input from precipitation amounts to about 30 kg/ha/yr. This figure is 5% or less of usual lime requirements for lands used in agricultural production. Work is in progress on studies of the regional representativeness of deposition monitoring sites and on the contribution of local emission sources of SD(2) and ND(x) to the precipitation chemistry of a region.

Publications: 83/10 to 84/09
 ND PUBLICATIONS REPDRTE THIS PERIOD.

04.033* CRIS085604
MEASUREMENT OF PRECIPITATION AT THE HUNTINGTON WILDLIFE FOREST

RAYNAL D J; Biology Chemistry & Ecology; State University of New York, Syracuse, NEW YORK 13210.
 Proj. No.: NYZ-2226-01-008 Project Type: STATE
 Agency ID: DCI Period: 06 JUN 80 to 31 MAY 86

Objectives: This project is designed to gather precipitation samples and dry deposition samples in the Central Adirondack Mountains as part of the precipitation monitoring network of the National Atmospheric Deposition Program (NADP). Supporting weather information will also be amassed. The information collected will support the college's efforts determining the actual and potential effects of acid precipitation on certain Adirondack forest ecosystems. The project will also result in an improved basis for evaluating the dynamic nature of precipitation chemistry in the Central Adirondack region.

Approach: Precipitation samples will be collected weekly and dry deposition samples bimonthly on a year-round basis using the Aero-Chem Metrics Model 201 precipitation sampling apparatus. Samples will be analyzed at the Adirondack Ecological Center Laboratory for reaction (pH) and specific conductance. Supporting weather information will be collected daily. All information will be transmitted to the NADP Central Analytic Laboratory (CAL) for further analyses including chemical constituent characterization.

Progress: 83/10 to 84/09. Atmospheric deposition was measured at Huntington Wildlife Forest in the central Adirondack Mountains in cooperation with the National Atmospheric Deposition Program during 1978-1983. Volume-weighted mean pH was 4.18 compared with the NADP lab measured value of 4.34. Annual wet deposition of sulfate measures 23 kg ha while nitrate deposition measures about 14 kg ha. Major mechanisms for input of ions to hardwood and conifer forests at Huntington Forest were studied. Transport of ions from atmosphere to forest floor were identified using regression analyses and the assumption that deciduous and coniferous forests capture particulate matter and aerosols with differing efficiencies. Impaction of suspended particulates and aerosols was an important source of sulfate and nitrate and these ions may contribute to leaching of calcium from foliage.

Publications: 83/10 to 84/09

MDLLITOR, A.V. and RAYNAL, D.J. 1983. Atmospheric deposition and ionic input in Adirondack Forests. Journal of the Air Pollution Control Association 33: 1032-1036.

04.034* ACID PRECIPITATION RESEARCH

CRIS0089959

BATEMAN D F; Agricultural Research Service; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
Proj. No.: NC09044 Project Type: SPECIAL GRANT
Agency ID: CSRS Period: 15 APR 83 to 31 JUL 84

Objectives: Determine the nature and magnitude of effects of atmospheric acid deposition on terrestrial ecosystems with primary emphasis on major agricultural crops of the United States.

Approach: Proposals will be solicited from the agricultural research community to study the impact of acidic and acidifying substances, from the atmosphere, on major agricultural crops. Greenhouse, field and laboratory investigations will be employed. Measurements will be made of plant response to variable doses of acidity including changes in physiological activity and in quality and quantity of biomass and crop yield. Ambient amounts of pollutant/nutrient deposition, both wet and dry, will be the primary focus for experimentation. Effects will be quantified relative to common agricultural practices.

Progress: 84/01 to 84/12. Ten projects are underway with the overall objective of improving understanding of the beneficial and/or detrimental effects of acidic and acidifying substances from the atmosphere on agricultural crops. Six institutions have received subcontracts: NCSU, University of Illinois, University of California-Riverside, University of Tennessee, VPI&SU, and Ohio University. Specific research activities include the epidemiology of major crops when impacted by acid deposition, interaction between ozone and acid deposition, impact of acid fog on major California crops, and extensive screening of agricultural species for sensitivity to acidic deposition. The specific projects funded all fall within the research priorities identified by the National Atmospheric Deposition (IR-7) - Technical Committee.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

04.035

CRIS0087076

THE ASSESSMENT OF AIR QUALITY EFFECTS ON CROP PRODUCTION

HECK W W; BLUM U; Botany; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
Proj. No.: NC05520 Project Type: STATE
Agency ID: SAES Period: 01 JAN 82 to 30 SEP 86

Objectives: Assess the effects of D(3) and SD(2) on crop production and how these gases affect the crops; determine the primary site of action; and initiate the development of redictive capabilities. Develop some fundamental understanding of the effects of acidic precipitation and carbon dioxide on crop production.

Approach: Experiments will utilize the Continuous Stirred Tank Reactor (CSTR) chambers in greenhouse and Phytotron studies and the open-top chambers for field work. All chamber systems utilize continuous gas analyzers on a shared-time basis for monitoring pollutant concentrations. The CSTR chambers are designed for gas exchange studies and routine monitoring of CO(2), water vapor and test gases can be made at the chamber inlet or outlet. Plant response determined will be dictated by the objectives of the experiment. Exposures will be episodic or chronic over the life of the plant. Rate functions will be generated in many studies.

Progress: 84/01 to 84/12. Pool concentrations of glycine, serine and pyruvic in white clover (*Trifolium repens* L. cv.) 'Tillman' grown under 550 micro E m-2s-1 (PAR) were significantly reduced within 24 hr after transfer of plants to 285 micro E m-2s-1. These reduced concentrations stabilized in the 2nd trifoliate within three days. Data suggest that when plants are transferred from one environment to another they should have from one to three days to acclimate before metabolic studies are undertaken. Plants so acclimated for 91 hr and then exposed to ozone (0.15 ppm, 4 hrs) showed an initial reduction in glycine

and serine in the 2nd trifoliolate leaves. The concentration of each metabolite then increased with increasing exposure time to 4 hrs. There was no effect on ozone on 6-phosphogluconic acid. Phaseus vulgaris lines were screened for relative susceptibility to O₃ (1186 lines) and SO₂ (58 lines). Seed increases were done on a sampling of these lines for more in-depth studies. The field studies utilized 3 resistant and 3 sensitive bean lines (3 ozone concentrations, 4 SO₂ concentrations, and 2 reps) in a split plot design. The relative resistance/sensitivity separations reported in the Phytotron screen were substantiated in the field study. Computerization of the bean data base was completed.

Publications: 84/01 to 84/12

- BLUM, U., MROZEK, E. JR., and JOHNSON, E. Investigation of ozone (O₃) effects of 14C distribution in Ladino clover. Environmental and Experimental Botany. 23(4):369-378.
- BLUM, U., HEAGLE, A.S., and LINTHURST, R.A. 1983. The effects of ozone on fescue-clover forage production: regrowth, yield, and quality. Environmental and Experimental Botany. 23(2):121-132.
- HECK, W.W., BLUM, U., REINERT, R.A., and HEAGLE, A.S. 1983. Effects of air pollution on crop production. In "Strategies of Plant Reproduction." pp. 333-350. Allanheld, Osmun & Company Publishers, Inc., Totowa, NJ.
- MONTES, R.A., BLUM, U., HEAGLE, A.S., and VOLK, R.V. 1983. The effects of ozone and nitrogen fertilizer on tall fescue, ladino clover and fescue-clover mixture. II. Nitrogen content and nitrogen fixation.
- HECK, W.W., BLUM, U., BOSS, W.F., HEAGLE, A.S., LINTHURST, R.A., REINERT, R.A., REYNOLDS, J.F., and ROGERS, H.H. Perspectives of air pollution research on plants. In Reviews of Environmental Toxicology I. E. Hodgson, ed., pp. 173-249.

04.036 CRIS0042179 EFFECTS, FATES AND TRANSFORMATIONS OF ATMOSPHERIC CHEMICALS ON PLANT GROWTH AND DEVELOPMENT

HECK W W; HEAGLE A S; REINERT R A; Field Crops Post-harvest Res Biomaterials Conversion Lab; USDA Agricultural Research Service, Raleigh, NORTH CAROLINA 27607.
Proj. No.: 6645-20790-002-00D
Project Type: INHOUSE
Agency ID: ARS Period: 17 JAN 75 to 30 SEP 85

Objectives: Investigate: biochemical, physiological & growth responses of plants to atmospheric chemicals; dose-response relationships as the primary experimental protocol; plant response as affected by environmental & biotic factors; continued improvement of exposure methodology; plants as sinks for atmospheric chemicals.

Approach: Use the continuous stirred tank reactor CSTR exposure system for greenhouse & phytotron control of atmospheric chemicals. Open-top chambers will be used for field

studies with automated dispensing & monitoring systems & computer controlled data acquisition. Special rain dispensing (greenhouse & field) & rain exclusion (field) systems will be developed, tested, & used for acid rain studies (as part of the acidic precipitation research). Initially we will use both acute & acute-chronic dose-response exposure regimes. Plant responses include: chemical uptake or release, net photo-synthesis, transpiration rate, stomatal response, growth & yield parameters, nutrient ratios, changes in metabolic pools, plant injury. Meteorological studies will be integrated with field studies to help interpret & predict plant response on a national basis. Response measures may be measured over time to develop rate functions.

Progress: 82/01 to 82/12. Yield of unginned cotton at seasonal 7 hr./da. O₃ conc of about 0.03, 0.05, 0.07, 0.09 and 0.11 ppm. O₃ was 3650, 3180, 2780, 2200 and 1600 kg./ha., respectively. Sulfur dioxide at seasonal 4 hr./da. SO₂ conc of 0.00, 0.03, 0.12 and 0.36 ppm. did not decrease cotton growth or yield and did not measurably change cotton response to O₃. An increase in soybean yield and growth was found with increasing CO₂ in season-long studies with elevated CO₂ for 24 hr./da. The first 200 ppm. of CO₂ over ambient caused the greatest effect. Increases in germination and seed development were not affected by CO₂. Uptake of O₃ was shown to be controlled mainly by stomatal resistance (r(s)) which was similar for plants grown in the field and in open-top chambers. Low concentrations of NO₂, SO₂, and O₃ in various mixtures caused reduced yields of soybean and snap bean when compared with control plants in charcoal-filtered open-top chambers. Snap bean lines selected as resistant or sensitive to O₃ in an acute phytotron screen (using visible injury) maintained their relative resistance/sensitivity for yield response in a chronic field exposure to O₃ (using open-top chambers). Approximately 50 additional O₃ resistant snap bean lines have been identified from a screen of 1150 lines. An acid rain exclusion system was designed and tested with soybean. Effects of increasing rain acidity were not found in these preliminary tests.

Publications: 82/01 to 82/12

- HEAGLE, A.S. and LETCHWORTH, M.B. 1982. Relationships between injury, growth and yield effects of ozone on four soybean cultivars at different light intensities. J. Environ. Quality 11:690-694.
- HECK, W.W. 1982. Future directions in air pollution research. In: Effects of Gaseous Air Pollution in Agriculture and Horticulture. (Unsworth, M.H. and Ormrod, D.P. Eds.) pp. 411-435. Butterworth Scientific, London.
- HECK, W.W., TAYLOR, O.C., ADAMS, R., BINGHAM, G., MILLER, J., PRESTON, E., and WEINSTEIN, L. 1982. Assessment of crop loss from ozone. J. Air. Pollu. Contr. Assoc. 32:353-361.
- JOHNSTON, J.W. and HEAGLE, A.S. 1982. Response of chronically ozonated soybean plants to an acute ozone exposure.

04.037 CRIS0076598
**CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND
 EFFECTS ON LAND AND SURFACE WATERS**

ENZ J W; BRUN L J; Soil; North Dakota State University, Fargo, NORTH DAKOTA 58105.
 Proj. No.: ND02544 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 78 to 30 SEP 83

Objectives: Establish an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the U.S.

Approach: Samples of precipitation and dry particulate matter will be collected weekly from one site in N.D. and will be analyzed at a Central lab for SO(4), NO(3), PO(4), C1, NH(4), K, Na, Ca, Mg, pH, total and free acidity, and electrical conductivity. Temporal trends will be investigated from these data. DEPOSITION-MONITORING.

Progress: 83/01 to 83/12. Discussions of the merits of several research proposals were conducted with USGS and State Health Department personnel. The proposed projects all relate to soil and/or plant sampling and analysis for heavy metals near mine and/or power plant sites. Preparation of a project proposal is anticipated next year.

Publications: 83/01 to 83/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

04.038 CRIS0078945
**AIR POLLUTANT IMPACTS ON RADIAL INCREMENT OF
 FOREST TREES**

MCCLLENAHEN J R; DOCHINGER L S; Environmental Studies Lab; Ohio Agric Res and Devlp Center, Wooster, OHIO 44691.
 Proj. No.: OH000284-SS Project Type: STATE
 Agency ID: SAES Period: 08 JAN 79 to 30 NOV 82

Objectives: To determine the applicability of tree-ring analysis techniques to the detection and assessment of air pollutant impacts on radial growth of forest trees; To investigate potential relationships between radial tree increment and air pollutant exposure in airsheds of specific point and area sources.

Approach: Tree-ring chronologies based on ring-width indices will be developed for several tree species in stands growing on sites remote from air pollutant sources. The chronologies will be compared by analysis of variance, correlation analysis, digital filtering, and other procedures used to study effects of environment on ring width variation.

Progress: 79/02 to 82/11. Air monitoring and atmospheric deposition data were used as a partial basis for assessing the relative pollutant dose received by areas in southeastern Ohio for which Quercus alba L. tree-ring chronologies were developed. The chronology of ring-width indices (RWI) for a

low-dose area was calibrated with local climate. The resulting regression model was then used to predict RWI for Q. alba at three sites exposed to higher pollutant levels. Comparison of the actual RWI at these sites with those predicted on the basis of climate (mean monthly temperature and total monthly precipitation) corresponded poorly during approximately 20-year moving correlation periods beginning after 1920 and also after about 1955. Further, climatic calibrations using chronologies from the three high pollutant exposure sites showed trends of decreasing correlation with actual RWI (i.e., poorer fit) beginning about 1930. This evidence points to a non-climatic influence on white oak growth in this region that corresponds with the growth of steel and chemical industries there.

Publications: 79/02 to 82/11
 NO PUBLICATIONS REPORTED THIS PERIOD.

04.039* CRIS0093520
**THE ECONOMICS OF RESIDUALS: SOIL EROSION AND
 SEDIMENT; SLUDGE AND SOLID WASTE; ACID RAIN**

FORSTER D L; SOUTHGATE D JR; HITZHUSEN F J; Agri Economics & Rural Sociol; Ohio State University, Columbus, OHIO 43210.
 Proj. No.: OH000780 Project Type: HATCH
 Agency ID: CSRS Period: 01 AUG 84 to 31 OCT 87

Objectives: Explore the economics of technically viable options for controlling soil erosion and sediment deposition in the East Fork of the Little Miami River Basin (Southwestern Ohio) and the Valdesia Watershed (Dominican Republic), recycling sludge, metals and other valuable residuals, and reducing both source emissions and receptor damage from acid rain.

Approach: The analysis of soil erosion and sediment control requires estimates of costs and benefits for three groups - farmers, downstream water users, and future generations of producers. Also, options for controlling erosion may impact regional economics, and these will be investigated through regional input-output models. Analysis of recycling sludge and other residuals requires estimates of benefits and costs. The focus will be economics of size in composting plants and the effect of composting on wastewater treatment costs. Cost effectiveness estimates will be made for options to control acid rain. Also, institutional mechanisms for dealing with the spillover aspects of acid rain will be inventoried.

Progress: 84/08 to 84/12. D. Southgate was one of two principal investigators on a study of the feasibility of using heat generated at the Piketon, Ohio uranium enrichment facility to heat a greenhouse complex. Five faculty members and three graduate students participated in the study, which was funded by DOE. In addition to the final report, manuscripts based on project research have been submitted to J. Am. Soc. Hort. Sci. and J. Northeastern Ag. Econ. Council. Articles describing research on third world soil erosion

problems written by Doug Southgate, Fred Hitzhusen, and others have appeared or will shortly appear in Am. J. Ag. Econ., Land Econ., and Water International. Papers on the same topic were presented at the East-West Center and at annual meetings of the Am. Ag. Econ. Assoc., and the Soil Conservation Society of America. Forster's work in the area of soil erosion and sediment has resulted in two manuscripts being accepted for publication. One reported the results of six years of work in the Lake Erie Basin. It describes a program to reduce pollutant loads to Lake Erie. The other manuscript reports estimates of off-farm costs of oil erosion in northwestern Ohio.

Publications: 84/08 to 84/12

- FDRSTER, D.L. and ABRAHAM, G. 1985. "Sediment deposits in drainage ditches: a cropland externality," Journal of Soil and Water Conservation.
- FORSTER, D.L., LOGAN, T.J., YAKSICH, S.M. and ADAMS, J.R. 1985. An accelerated implementation program for reducing diffuse source phosphorus load to Lake Erie. Journal of Soil and Water Conservation.

04.040 CRISO085357
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY SURFACE WATERS, AND MATERIALS

LYNCH J A; School of Forest Resources; Pennsylvania State University, University Park, PENNSYLVANIA 16802.
 Proj. No.: PEN02657 Project Type: HATCH
 Agency ID: CSRS Period: 01 DCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the following: productivity of agricultural crops and forest trees, health and productivity of domestic food animals, wildlife, and fish, chemical composition of surface and ground waters, and atmospheric visibility and the corrosion of metals and other materials in machinery or structure.

Approach: Collect and process samples as a part of the collection network. Identify advantages and limitations of individual rain or storm events, weekly, biweekly, and monthly of collection.

Progress: 84/01 to 84/12. An atmospheric deposition monitoring site has been established on the Leading Ridge Experimental Watersheds in Huntingdon County, Pennsylvania. This monitoring site is part of the National Atmospheric Deposition Program (NADP) that was initiated to determine trends in the supply of both beneficial and potentially injurious substances in precipitation deposited in various regions of the U.S. Chemical analyses of 1984 samples indicate that precipitation in Pennsylvania continues to be very acidic with an average annual pH of about 4.1. Growing season precipitation was more acidic (pH= 4.0) than dormant season precipitation (pH= 4.4).

Ca, Mg, K, NH(4), and C1 were also present in precipitation but at very low concentrations. The dominant ions in precipitation were H, SD(4), and NO(3). SO(4) and NO(3) ions were strongly correlated with precipitation pH. Data from this and other NADP sites indicate that highly acidic precipitation occurs over all of the Northeast and that the 1984 data were similar to those observed during the preceding 3 years.

Publications: 84/01 to 84/12

- LYNCH, J. A., 1984. Atmospheric deposition: spatial and temporal variations in Pennsylvania in 1983. Ann rept to Pa Dept Env. Res. Inst. Res. Land & Water Resour. University Park, PA 228P.
- DANN, M. S. 1984. Assessing methods of stream nutrient export determination. M.S. Thesis. Penn State University, University Park, PA 57p. (The work upon which this thesis is based was supported under AES Project 2449).
- LYNCH, J. A., CORBETT, E. S., MUSSALLEM, K. (In press). Best management practices for controlling nonpoint source pollution on forested watersheds. Jour. of Soil and Water Cons.
- LYNCH, J. A. 1984. Atmospheric deposition and stream ecosystems: constraints in assessing relationships. "In": Proc. on Air Pollution and the Productivity of the Forest. Washington, D.C. Dct. 1983. pp. 229-240.

04.041 CRISO090259
MECHANISMS OF ACID RAIN FORMATION: A PHOTOCHEMICAL STUDY

ISABEL RDY J; Natural Sciences; South Carolina State Coll, Drangeburg, SOUTH CAROLINA 29115.
 Proj. No.: SC.X-120-07-83 Project Type: 1890/T
 Agency ID: CSRS Period: 19 MAY 83 to 18 MAY 88

Objectives: The primary objective of this project is to determine and quantify some of the photochemical processes occurring in the troposphere that lead directly or indirectly to formation of acid rain precursors SOx and NDx, and ultimately to H2SD4 and HN03, end products, found in acidic precipitation.

Approach: Mechanisms of Acid Rain formation will be studied using a combination of available collective information on air quality measurements by the South Carolina Dept. of Health and Environmental Control and experimental methods devised to monitor photochemically produced gas phase radical and intermediate species. Environmental chamber contents will be analyzed (after solar irradiation) using the low temperature spectroscopic technique of Matrix-Isolation in conjunction with Fourier Transform Infrared Spectroscopy and Laser Raman Spectroscopy. Spectral data will be subjected FT-IR computer analyses including spectra subtraction, multicomponent analysis, peak picking, and spectral library search.

Progress: 83/10 to 84/09. Work on this project is in its initial stages. Progress, thus far, has involved efforts to set up the

experimental laboratory. The basic analytical instrumentation, a Fourier Transform Infrared Spectrometer/Data System, has been purchased and is operational. Routine test experiments have been performed on it. A dual mixing chamber for establishing mixing ratios for acid rain precursors has been installed and is partially operational. The system is being fitted with sensors to monitor pressure, temperature, and humidity. Future modifications of this system will include the installation of a solar radiation simulator for photolysis of chamber contents. Experimental protocol will involve the establishment of appropriate mixing ratios of acid rain precursors, photolysis with solar radiation, and spectroscopic analysis (simultaneous and sequential) of chamber contents via gas phase and condensed phase (matrix-isolation) methods. Several items of major equipment are to be purchased during the current year. These include a Carbon Dioxide (CO₂) Laser, and a Xenon Arc Solar Radiation Simulator.

Publications: 83/10 to 84/09
NO PUBLICATIONS REPORTED THIS PERIOD.

04.042 CRIS0089838
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS AND
MATERIALS**

GARDNER W; Plant Science; S Dakota State
University, Brookings, **SOUTH DAKOTA** 57007.
Proj. No.: SDO0502 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Objectives: 1. To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. 2. To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife, and fish, c) the chemical composition of surface and ground waters; and d) atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery of structure.

Approach: Since 1979 the NC-141 regional project has become known, both nationally and internationally, as the National Atmospheric Deposition Program (NADP). The 168 scientists and 100 research sites that are presently affiliated with the NADP will form the core of scientific resources.

Progress: 84/01 to 84/12. Dilute aqueous solutions of sulphuric and nitric acids (1:1,V:V) were applied to foliage and/or soil or greenhouse potted plants. Mists of pH 5.6, 3.5, 2.5, 2.0 and 1.8 on corn 'N28', tomato 'Rutgers' and sorghum 'HOK' leaves resulted in no visible injury at pH 5.6 and 3.5. Widely scattered very small necrotic spots developed at pH 2.5, moderate necrotic spots at pH 2.0 and severe leaf necrosis developed at pH 1.8. Corn was grown in 13 cm soil (loam/sand 2:1) pots and irrigated with pH 5.6, 3.5, 2.5, 2.0

and 1.8 at 100ml of each acid solution each week for 7 weeks. Plant height, green leaf color and dry weight were significantly greater at pH 1.8 and 2.0 than the other pH treatments. In a sand/peat (1:1) soil mixture, tomato fresh weight, dry weight and plant height were 477%, 501% and 171% respectively greater for pH 1.8 soil treatment compared with the soil treatment at pH 5.6. In the absence of foliar treatment on corn and tomato, soil application of pH 1.8 resulted in a highly significant growth response. 'Xanthi N' tobacco leaves were mechanically inoculated with tobacco mosaic virus (TMV) and 30 seconds after inoculation half/leaves were dipped for one minute in dilute solutions of sulphuric/nitric acid at pH 5.6, 3.5, 2.5, 2.0 and 1.8. Local lesions were significantly reduced in all of 9 trials at pH 2.5, 2.0 and 1.8. In 5 trials, pH 3.5 produced more local lesions. In 2 trials pH 5.6 produced more local lesions and in 2 trials pH 3.5 and 5.6 were about equal in local lesion development.

Publications: 84/01 to 84/12
GARDNER, W.S. 1984. Response of hard red spring wheat to dilute sulphuric/nitric acid mists. Ann. Wheat Newsletter 30:163.

CM 05 RECREATIONAL RESOURCES

05.001* CRISO088451
PEDOLOGIC INVESTIGATIONS IN SUPPORT OF ACID
RAIN STUDIES, SEQUOIA NATIONAL PARK, CALIFORNIA

HUNTINGTON G L; Land, Air & Water Resources;
University of California, Davis, CALIFORNIA
95616.

Proj. No.: CA-D*-LAW-4265-H Project Type: HATCH
Agency ID: CSRS Period: 30 AUG 82 to 30 SEP 86

Objectives: In cooperation with Sequoia National Park, project will: study, determine and map the vertical zonation patterns of soil subgroups on the watersheds between the Middle and Marble Forks of the Kaweah River; assist Park Service in using the data to select long term sites for base-line acid rain studies; provide detailed pedography for selected sites as part of evaluative base for ecological effects of acid rain.

Approach: A third order soil survey will be made within subject area. Dominant vegetation will be related to delineated soil subgroups. Orthophoto soil maps of the area will be made for guidance in meaningful selection of acid-rain study sites in the varied geologic and climatic zones within the Park. Detailed soil studies and maps will be made for the selected sites later.

Progress: 84/01 to 84/12. All soil map units reviewed and correlated in Soil Taxonomy for the ultra-detailed (Order 1) mapping of acid rain study sites, and for the reconnaissance (Order 4) mapping of the acid rain study region in Sequoia National Park. All laboratory soil characterization data reviewed and checked; descriptions of the sites and profiles prepared for all sampled reference pedons; data and descriptions assembled into 2 appendices for the project's report to the Park Service. Masters for the map printing plates prepared for the Order 4 map. Final map will consist of 7 sheets, scale 1:24000, on an orthophoto base. Sites selected for a special study transect of soil climate within the Sequoia NP acid study region. Special equipment has been obtained to initiate this study in the summer of 1985. Transect designed to look at soil-vegetation-elevation relationships to soil temperature and moisture regimes, as currently defined in Soil Taxonomy, in the mixed conifer to sub-alpine zones of the Sierra Nevada. No data currently exists. Needed to verify or modify classification of some of the soils in the Sequoia acid rain study region. Data also needed to correlate with other western regional soil climate studies.

Publications: 84/01 to 84/12

HUNTINGTON, G.L. and AKESON, M. 1984. The Soils of Sequoia National Park: Ash Peaks Ridge to Triple Divide Peak. Abstracts of Presented Posters and Papers, Second Biennial Conf. of Research in California's National Parks.

05.002* CRISO083194
ECONOMIC ANALYSIS OF NATURAL RESOURCE AND
ENVIRONMENTAL ISSUES IN COLORADO

YOUNG R A; WALSH R G; HUSZAR P C; Economics;
Colorado State University, Fort Collins,
COLORADO 80523.

Proj. No.: COL00328 Project Type: HATCH
Agency ID: CSRS Period: 08 AUG 80 to 30 SEP 83

Objectives: Objectives---The overall objective of the research is to study the demand, supply and economic value of Colorado Natural resources and environmental commodities, and to evaluate market and non-market allocative mechanisms for achieving maximum social return from the resources.

Approach: Analyze the value of water in withdrawal uses (agriculture, households, industries and non-withdrawal uses (recreation); Investigate the economic forces underlying conservation of rural lands to urban uses and evaluate alternative public policies for influencing land use and the extent of urban sprawl evaluate the demand for the management of outdoor recreation on public lands and waters. Evaluate the impact of growing demand for energy on Colorado's economy and environment. Study the economic impacts of natural hazards. Evaluate the economic benefits of air and water quality improvement. Formulate and test new methodologies for ascertaining the economic impacts (in allocative, distributive, and regional dimensions) of changes in the demand for non-marketed environmental goods and services.

Progress: 83/01 to 83/09. The overall objective of this research program is to study the demand, supply and economic aspects of Colorado's natural resources and environmental endowments, to evaluate market and non-market allocation mechanisms for achieving optimal social returns from natural resources, and to assist in conflict resolution via public policy analysis arising from competing uses of these resources. During this time period, research continued on water use allocations and quality aspects, groundwater use in agriculture, an updating of Colorado water case law, option demand for recreational uses, values of hunting and fishing in Colorado, some preliminary work on the grasslands plowout problem in eastern Colorado, and related natural resource economics issues. Due to reorganization of agricultural programs at CSU, a new Department of Agricultural and Natural Resource Economics was established in the College of Agricultural Sciences on July 1, 1983. As a result of this action, this project (Colo 328) is being terminated and will be replaced by a new reoriented research project, "Natural Resource Economics and Regional Resource Allocation Issues", effective October 1, 1983.

Publications: 83/01 to 83/09

DAVITT, G.J. and WALSH, R.G. 1983. A demand function for length of stay on ski trips to Aspen. Journal of Travel Research. 21(Spring).

MCKEAN, J.R. and WEBER, J.C. 1983. The economy of Lincoln, Sublette, Sweetwater and Uinta Counties, Wyoming, Rock Springs.

- BLM District, Technical Report No. 40, Colorado Water Resources Research Institute, Colorado State University.
- MCKEAN, J.R. and NOBE, K.C. 1983. 1981 Colorado sportsman survey: Direct and indirect effects of expenditures for hunting and fishing in Colorado (Contract Report for Colorado Division of Wildlife and Bureau of Land Management).
- GILLIAM, L.O., MILLER, N.P. and WALSH, R.G. 1983. Congestion and willingness to pay for expansion of skiing capacity. Land Economics 59. (May 1983).
- GILLIAM, R.A., LOOMIS, J.B. and WALSH, R.G. 1984. Valuing option, existence, and bequest demands for wilderness. Land Economics 60. (February 1984).

CM 06 TREES, FORESTS, AND FOREST PRODUCTS

06.001* CRIS0096913 EFFECTS OF ATMOSPHERIC DEPOSITION ON FOREST RESOURCES IN ARKANSAS

BEASLEY R S; Forest Resources; University of
Arkansas, Monticello, ARKANSAS 71655.
Proj. No.: ARK01228

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 NOV 85 to 30 SEP 90

Objectives: To evaluate research programs designed to verify cause-effect relationships between forest decline and atmospheric deposition in Europe and the eastern U.S.; to characterize the current composition of precipitation, streamflow and soils in forest ecosystems in Arkansas and to determine the extent to which hydrologic processes; flow pathways and ecosystem characteristics modify or buffer acidic deposition; and measure long-term changes in atmospheric deposition and determine the effects of such changes on stream chemistry, aquatic organisms, soil properties and forest productivity.

Approach: Experimental forested watersheds in the Gulf Coastal Plain, the Athens Plateau and the Ouachita Mountains have provided detailed information on the hydrology and water chemistry of forest ecosystems in each physiographic province. These data will provide background information for expanding the work to evaluate effects of atmospheric deposition on forest soils, stream chemistry and forest productivity. Since measuring, sampling and collection devices are in place our initial work will involve additional soil and water chemical analyses such as sulfate, aluminum, pH and conductivity. The evaluation of flow pathways will require collection trenches to intercept and sample subsurface and overland flow. Initial work will be concentrated in the Ouachita Mountains where soils and streams are highly sensitive to acidification due to inherently low alkalinity.

06.002 CRIS0080010 DIAGNOSIS OF WOOD DECAY

WILCOX W W; Forest Products Laboratory;
University of California, Berkeley, CALIFORNIA
94720.

Proj. No.: CA-B*-FPL-3879-MS
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 86

Objectives: Generate and evaluate sufficient microscopical data on wood at known stages of decay, particularly early stages of decay, facilitate accurate estimation of the degree of decay in samples taken from wood in service. Evaluate and refine non-destructive methods of detecting wood decay in order to make them applicable to the accurate detection diagnosis of early stages of decay in wood in service.

Approach: Samples of known stages of decay, as determined by weight loss, will be prepared by accelerated laboratory culture methods. They will be embedded, sectioned, examined and

photographed microscopically. Photomicrographs will be compared and examined for trends. Tests equipment will be applied to both laboratory samples of known decay and to wood decayed in service.

Progress: 84/01 to 84/12. The focus of this research continued to be the detection, diagnosis and evaluation of wood biodeterioration in structures. Research continued on the role played by actinomycetes in the decomposition of wood in soil contact. Nearly all of the actinomycetes isolated by a variety of means have been members of the genus *Streptomyces*. All isolates have so far proven incapable of producing significant weight loss in wood. Results of a study of treated wood in Hawaii were published. The social and political setting of an island economy was found to significantly affect the quality of treatment available and the opportunity for improvement which would normally be the case on the mainland. Final publications from the research on failure of specimen giant sequoia were completed. The major cause of uprooting and breakage appears to be root rots brought to the sequoias by the ingrowth of true fir following suppression of fire under park management. To maintain the health of mature sequoias and provide sequoia regeneration it appears necessary to remove or prevent the ingrowth of a true-fir understory in giant sequoia groves. Research on the effects of ozone--as an oxidant air pollutant--on the rate of decay of wood on the forest floor suggests that relatively high ozone concentrations have no significant effect on decay rate.

Publications: 84/01 to 84/12

- PIIRTO, D.O., WILCOX, W.W., PARMETER, J.R., JR. and WOOD, D.L. 1984. Causes of uprooting and breakage of specimen giant sequoia trees. Univ. of California, Division of Agriculture and Natural Resources, Bulletin 1909, 16 pp.
WILCOX, W.W. and OLDHAM, N.D. 1984. Effects of atmospheric ozone on wood decay. Calif. For. and For. Prod. 52: 4 pp.
WILCOX, W.W. 1984. The performance of Douglas-fir in normal residential service. Calif. For. and For. Prod. 53: 1 pp.
PIIRTO, D.O., PARMETER, J.R., JR and WILCOX, W.W. 1984. Basidiomycete fungi reported on living or dead giant sequoia or coast redwood. Calif. For. and For. Prod., 55: 4 pp.
WILCOX, W.W. 1984. Observations on structural use of treated wood in Hawaii. For. Prod. J. 34(5):39-42.

06.003* CRIS0089881 CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

BURGY R H; CARROLL J J; FLOCCINI R G; Land,
Air & Water Resources; University of
California, Davis, CALIFORNIA 95616.
Proj. No.: CA-0*-LAW-4311-RRProject Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America.

Approach: Studies will be conducted to identify and improve efficiency for collection of naturally- and anthropically-generated gaseous and particulate components added to, distributed by and deposited from the atmosphere which may have beneficial or injurious impact on components of terrestrial and aquatic ecosystems. Major sources and composition of atmospheric pollutants and atmospheric processes involved in their distribution and deposition will be investigated.

Progress: 84/01 to 84/12. During 1984, the Davis site operated on a continuous basis to monitor precipitation deposition. This portion of the project is attempting to identify acidic deposition products contained in rain samples and to define the sources of acidic constituents that contribute to acidity of rainfall here. The program was modified on July 1, 1984 to discontinue collections of dry deposition samples (only a few stations in the U.S. will take dry samples hereafter). The Davis site was inspected by NADP this year and minor adjustments in equipment were made to conform to network specifications. A total of 20 rain samples were collected in the year, these yielding pH values ranging from 5.0 to 6.5. The average of all samples is about 5.8 pH units, indicating a nearly neutral acidity in Davis rainfall. Spring rains tend to have higher pH values (about 6.0) and Fall rains tend to be lower (5.0 to 5.5), suggesting some effect due to strong inflow in early winter storms that generally translate into the upper delta area (Davis) from the southwest and include trajectories passing over the metropolitan bay-delta region. The limited numbers of events sampled makes all interpretations inconclusive, and will require longer experience to resolve.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

machinery or structure.

Approach: Studies will evaluate sensitivity of soils, waters, and terrestrial and aquatic organisms to atmospheric deposition, chemical and biological processes in soils, waters and organisms affected by atmospheric deposition, and terrestrial processes and agricultural and forest practices as may influence effects of deposition on aquatic systems.

Progress: 84/01 to 84/12. Investigations under this project contribute to an integrated long-term study of potential impacts of atmospheric deposition on terrestrial and aquatic ecosystems of the Sierra Nevada. Centered in Sequoia National park, this project focuses on buffering characteristics of soils of the program study area, on release of chemical elements from the soils in response to acidity and alkalinity inputs, on mechanisms involved in dissolution and transport of mineral elements and on the input-output balance for sulfuric acid added to the soil systems. A total of 26 surface profile samples from representative soils have been subjected to a buffer performance test involving graded additions of H_2SO_4 and $Ca(OH)_2$. The pH of the systems was measured weekly for 6 weeks to observe the time course of buffering for each profile sample. Aqueous extracts from treated samples have been analyzed for major cations and anions. The pH data have been transformed into van Slyke buffering index curves and apparent sulfate adsorption has been calculated. The mineralogy has been qualitatively determined for silt and clay fractions of 12 of the surface profile samples. Buffering and sulfate adsorption have been unexpectedly strong in many samples while element release has been unexpectedly small. In addition to a wide diversity of phyllosilicate minerals in different soils of the area, there is a relatively high proportion of glass in a number of surface samples, suggesting a volcanic ash deposition source.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

06.004* CRISO089880
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

WHITTIG L D; BURAU R G; HUNTINGTON G L; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-4312-RR Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in

06.005 CRISO068726
NUTRIENT CYCLING IN NORTHERN CALIFORNIA TRUE FIR FORESTS

MCCOLL J G; Plant & Soil Biology; University of California, Berkeley, CALIFORNIA 94720.
Proj. No.: CA-B*-PSB-3789-MS
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 04 SEP 75 to 30 SEP 84

Objectives: Assess effects of various silvicultural treatments on nutrient cycling processes in true fir forests.

Approach: Effects of thinning and nitrogen-fertilization treatments on the retention and release of nitrogen from the litter layer, its transport in the soil solution will be studied. Studies of the cycling of other nutrients and elements involved in podzolization and assessment of possible site alterations due to timber

harvesting, will constitute later stages of this project.

Progress: 81/01 to 81/12. Timber harvest and site preparation effects on soil nutrient mobility have been studied since 1977 on an Ultic haploxeralf in a highly productive mixed-conifer forest of California's Sierra Nevada. New and older clearcut, shelterwood, and uncut stands were contrasted using tension lysimetry in the field and laboratory incubations of intact soil cores. Soils warmed sooner on treated sites and averaged 5 C warmer throughout the summer. Clearcutting increased soil moisture content and extended its period of availability. Soil nitrate NO₃ concentrations at 1 m depth rose only slightly the first year after clearcutting, but amounts totaled twice those in the control because of greater soil moisture. Slash burning increased NO₃ concentrations 5-fold. Amounts of nitrate were 15 times greater in the clearcut after a decade, but approached controls by crown closure at age 12. Laboratory trials suggest that temperature, moisture, and NH₄/4 substrate constrain nitrification on undisturbed sites. Leachate from litter of *Pteridium aquilinum* reduced nitrification when these constraints were removed. Cation analyses of soil leachates, and interactions between management practices and effects of acid rain are still being compiled. Three graduate students and periodic undergraduate student help.

Publications: 81/01 to 81/12
NO PUBLICATIONS REPORTED THIS PERIOD.

06.006* CRIS0062810
UTILIZATION, CONVERSION, AND MANAGEMENT OF SOUTHERN CALIFORNIA BRUSHLAND

YOUNGNER V B; NUDGE F J; Botany & Plant Sciences; University of California, Riverside, CALIFORNIA 92521.
Proj. No.: CA-R*-BPS-2861-H Project Type: HATCH
Agency ID: CSRS Period: 03 OCT 72 to 31 MAR 84

Objectives: Develop a basis for brushland utilization and management through studies on potential uses of brush species, effects of harvesting methods, substitution of exotic species, seedling establishment, competition among native and exotic species, physiology of resprouting.

Approach: Through field, greenhouse, growth chamber, and laboratory studies. Field studies will be in natural brushlands and field plantings, using portable research equipment. Laboratory analyses to plant tissue constituents and soil properties will be correlated with field observations. Specific environmental responses will be studied in greenhouse and growth chambers.

Progress: 84/01 to 84/03. Investigations of annual range plant responses to the air pollutants O₃ and SO₂ were conducted in fumigation chambers. In *Bromus rubens* ozone both reduced yield and affected several aspects of quality. Sulfur dioxide effects were less and primarily involved quality factors.

Interaction of the two pollutants was not shown. Chronic SO₂ exposure of *Bromus mollis* and *Erodium botrys* also resulted in yield reductions with carbohydrate allocation to the root zone being significantly reduced in *B. mollis*. *Erodium* growth showed some stimulation at the low SO₂ level but not at higher levels. Shoot sulfur content in *Bromus* was higher than in *Erodium* at comparable fumigation levels. Detrimental effects of fumigation were often not immediately apparent but developed as the season progressed. These studies indicated that air pollutants affect growth of brushland plants and may change species composition in affected areas. In some regions of high pollutant levels, value of the vegetation for forage and erosion control may be impaired and type conversion to species shown to be more tolerant may be desirable. Preparation of data for formal publication has continued.

Publications: 84/01 to 84/03
NO PUBLICATIONS REPORTED THIS PERIOD.

06.007 CRIS0093339
INTERACTION OF ACIDIC PRECIPITATION AND OZONE ON FOREST TREE SPECIES IN CALIFORNIA

TEMPLE P J; Statewide Air Pollution Res Ct; University of California, Riverside, CALIFORNIA 92521.
Proj. No.: CA-R*-2-2389
Project Type: SPECIAL GRANT
Agency ID: CSRS Period: 01 JUN 84 to 31 MAY 86

Objectives: The objectives of this research are to provide dose-response data on the impact of acid fog, alone and in combination with ozone, on foliar injury, shoot and root growth of western forest tree species; to determine the relative susceptibility of these tree species to combinations of acid fog and ozone.

Approach: Container-grown seedlings of selected western forest tree species will be exposed to simulated acid fog at pH 2.0, 3.2, 4.4, and 5.6 in outdoor fog chambers, then transferred to greenhouse chambers for exposure to ozone at 0, 0.10, or 0.20 ppm for 4 hours, 3 days per week from bud break to maturation of current year foliage. Visual injury symptoms will be recorded. Plants will be harvested and fresh and dry weights of leaves, stem, and roots will be measured.

06.008* CRIS0100000
THE ECOLOGY OF CHAPARRAL AND ASSOCIATED ECOSYSTEMS

CONRAD S; DUNN P; MILLER P; Pacific Southwest Forest and Range Experiment Station; USDA Forest Service, Riverside, CALIFORNIA 92507.
Proj. No.: PSW-1653 Project Type: INHOUSE
Agency ID: FS Period: 02 MAY 84 to 02 MAY 89

Objectives: To advance the understanding of the processes that determine nutrient status, erosion potential, water yield, plant community

development, productivity, and reproductive success in chaparral and associated ecosystems. Relate these processes to various land treatments, especially fire, and provide guidance to managers to help meet resource objectives.

Approach: Approach: To achieve better understanding of major ecosystem processes and to relate these processes to solving resource management missions, this Research Work Unit will utilize multidiscipline research techniques involving erosion hydrology, soil and plant. Sciences concerned with nutrient budgets, the relative microbiological sciences, physiological ecology, fire effects research, plant community development ecology, and air pollution research.

Progress: 83/10 to 84/09. RWU scientists have participated in the National Research Council analysis of landslides and flood disasters along Utah's Wasatch front. They have also developed (with the Geological Survey) a method to create soil slips on demand for research purposes. The National Atmospheric Deposition Program sampler on the San Dimas Experimental Forest gave some of the highest rates of nitrogen and sulfur deposition in the nation. A study of denitrification by nitrifiers was completed and a study of stream bed denitrification of smog-deposited nitrogen was started. Work was begun on the effects of dry deposition nutrients on leaf surface epiphytic microbes. Work was started on mixed ozone and sulfate smog on seedlings of sequoia and black oak. Tree ring analysis for historical effects of smog on tree growth was started in conjunction with the National Park Service. Thinning studies to ameliorate smog effects on oaks were accomplished. Preparations were made for a watershed-level study of smog nitrogen storage in chaparral soils and its release as the result of fire.

Publications: 83/10 to 84/09

- ANDERSON, L.R.; KEATON, J.E.; SAARINEN, T.; WELLS, W.G. The Utah landslides, debris flows, and floods of May and June 1983. Report CETS-CND-025. Washington, DC: National Academy Press; 1984. 90 p.
- MILLER, P.R. and WINER, A.M. Composition and dominance in Los Angeles basin urban vegetation. *Urban Ecology* 8: 29-54; 1984.
- MILLER, P.R. Ozone effects in the San Bernardino National Forest. In: *Proceedings of Symposium on Air Pollution and the Productivity of the Forest*. October 4-5, 1983; Washington, D.C.: Isaac Walton League of America.
- CONARD, S.G. Phenology of shrub species--its relevance to forest vegetation management. In: *Proceedings 5th Annual Forest Vegetation Management Conference*. Sacramento, CA. Nov. 2-3. 1983. Placerville, CA.
- CONARD, S.G.; EMMINGHAM, W.H. Herbicides for shrub control on forest sites in northeastern Oregon and northern Idaho. Special Publication 5. Corvallis, OR: Forest Research Laboratory. College of Forestry. Oregon State University; 1983.

06.009*

CRIS0064880

CHEMICAL REACTIONS IN SOILS AND THEIR EFFECT ON PLANT GROWTH

LINDSAY W L; BOYLE F W JR; WALTHALL P M; Agronomy; Colorado State University, Fort Collins, COLORADO 80523.

Proj. No.: COL00126

Project Type: HATCH

Agency ID: CSRS Period: 07 OCT 83 to 30 JAN 88

Objectives: Seed a basic understanding of the inorganic chemical reactions that occur in soils. Apply chemical principles to product and interpret elemental solubility relationships in soils. Relate solubility relationships of chemical elements to plant growth, nutrient deficiencies, elemental toxicities, nutrient imbalances, selection and use of fertilizers, and the formation and weathering of soils.

Approach: Chemical data from the literature will be computerized and used to predict chemical reaction and solubility relationships in soils. These models will be tested experimentally. Missing critical data will be identified. Carefully planned experiments will be established to obtain the missing information. The findings will be used to correct existing problems and to plan future experiments.

Progress: 83/10 to 84/09. Acid rain research in Rocky Mountain National Park shows the formation of smectite minerals which depress A_1 activity and allows the pH to drop into the range of 3.3 to 4.5. This is much lower than found in the Eastern U.S. where acidity problems are considered to be severe. Processed oil shales have undesirable pH values near 12. The high pH is the result of destructive loss of carbonates and formation of silicate minerals such as $CaSiO_3$ (wollastonite), $CaMg(SiO_3)_2$ (diopside), and $MgSiO_3$ (clinoenstatite). Recarbonation of such shales lowers the pH to 8.0 with the reformation of carbonate minerals. The effect of high pH and recarbonation on mineral transformations and solubilization of various metal ions is being studied. The cause of zinc deficiency in paddy rice is under investigation. Reducing conditions resulting from flooding greatly increased the solubilities of Fe and Mn which have a depressing effect on the uptake of zinc. Reduction caused the precipitation of $FeCO_3$ (siderite) and $Fe_3(OH)_8$ (ferrosic hydroxide), which raised the activity of Fe. We hypothesized that the increased activity of Fe depresses Zn activity through the formation for $ZnFe_2O_4$ (franklinite). This hypothesis will be examined further in subsequent studies. Activity measurements of Ca were made in both acid and calcareous soils. In calcareous soils Ca activities can be related to calcite equilibria.

Publications: 83/10 to 84/09

- LINDSAY, W.L. 1984. Soil and plant relationships associated with iron deficiency with emphasis on nutrient interactions. *J. Plant Nut.* 7:489-500.
- STUMPE, J.M., VLEK, P.L.G. and LINDSAY, W.L. 1984. Ammonia volatilization from urea phosphates in calcareous soils. *Soil Sci.*

Soc. Am. J. 48:921-927.

ELRASHIDI, M.A. and LINDSAY, W.L. 1984.

Fluorine supplement to Technical Bulletin 134: Selection of standard free energies of formation for use in soil chemistry. Colo. Agric. Exp. Sta., Fort Collins, Colorado.

06.010* CRIS0096764
THE EFFECT OF ATMOSPHERIC DEPOSITION ON SOILS, PLANTS, AND WATERS

REUSS J O; WALTHALL P M; LINDSAY W L;
 Agronomy; Colorado State University, Fort Collins, **COLORADO** 80523.

Proj. No.: COL00623 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 85 to 30 JUN 90

Objectives: To clarify the chemical processes that occur when soils are impacted by acid deposition, and the effects of these processes on the chemical composition of soil solutions and drainage waters. To evaluate the probability of deleterious effects occurring from current levels of deposition due to anthropogenic sources, the nature of such effects, their severity, and the time scale on which such effects are likely to be observed. To determine the probable effects of changes in current deposition levels, particularly acid deposition, on our soil, plant and water resources.

Approach: The general approach will involve a combination of theoretical studies using chemical models, and field and laboratory studies to evaluate the applicability of these models. Specific approach will include, but not be limited to, the following: 1. Development and testing of simple and accurate laboratory methods to determine input parameters required by current chemical models. 2. Field and laboratory testing of theoretical relationships utilized in chemical models. 3. Evaluation of cation replacement capacity of soil minerals. 4. Further model development, including refinement and expansion of current models and investigation of entirely different modelling approaches.

06.011* CRIS0083194
ECONOMIC ANALYSIS OF NATURAL RESOURCE AND ENVIRONMENTAL ISSUES IN COLORADO

YOUNG R A; WALSH R G; HUSZAR P C; Economics;
 Colorado State University, Fort Collins, **COLORADO** 80523.

Proj. No.: COL00328 Project Type: HATCH
 Agency ID: CSRS Period: 08 AUG 80 to 30 SEP 83

Objectives: Objectives---The overall objective of the research is to study the demand, supply and economic value of Colorado Natural resources and environmental commodities, and to evaluate market and non-market allocative mechanisms for achieving maximum social return from the resources.

Approach: Analyze the value of water in withdrawal uses (agriculture, households, industries and non-withdrawal uses (recreation); Investigate the economic forces underlying conservation of rural lands to urban uses and evaluate alternative public policies for influencing land use and the extent of urban sprawl evaluate the demand for the management of outdoor recreation on public lands and waters. Evaluate the impact of growing demand for energy on Colorado's economy and environment. Study the economic impacts of natural hazards. Evaluated the economic benefits of air and water quality improvement. Formulate and test new methodologies for ascertaining the economic impacts (in allocative, distributive, and regional dimensions) of changes in the demand for non-marketed environmental goods and services.

Progress: 83/01 to 83/09. The overall objective of this research program is to study the demand, supply and economic aspects of Colorado's natural resources and environmental endowments, to evaluate market and non-market allocation mechanisms for achieving optimal social returns from natural resources, and to assist in conflict resolution via public policy analysis arising from competing uses of these resources. During this time period, research continued on water use allocations and quality aspects, groundwater use in agriculture, an updating of Colorado water case law, option demand for recreational uses, values of hunting and fishing in Colorado, some preliminary work on the grasslands plowout problem in eastern Colorado, and related natural resource economics issues. Due to reorganization of agricultural programs at CSU, a new Department of Agricultural and Natural Resource Economics was established in the College of Agricultural Sciences on July 1, 1983. As a result of this action, this project (Colo 328) is being terminated and will be replaced by a new reoriented research project, "Natural Resource Economics and Regional Resource Allocation Issues", effective October 1, 1983.

Publications: 83/01 to 83/09

DAVITT, G.J. and WALSH, R.G. 1983. A demand function for length of stay on ski trips to Aspen. Journal of Travel Research. 21(Spring).

MCKEAN, J.R. and WEBER, J.C. 1983. The economy of Lincoln, Sublette, Sweetwater and Uinta Counties, Wyoming, Rock Springs BLM District, Technical Report No. 40, Colorado Water Resources Research Institute, Colorado State University.

MCKEAN, J.R. and NOBE, K.C. 1983. 1981 Colorado sportsman survey: Direct and indirect effects of expenditures for hunting and fishing in Colorado (Contract Report for Colorado Division of Wildlife and Bureau of Land Management).

GILLIAM, L.O., MILLER, N.P. and WALSH, R.G. 1983. Congestion and willingness to pay for expansion of skiing capacity. Land Economics 59. (May 1983).

GILLIAM, R.A., LOOMIS, J.B. and WALSH, R.G. 1984. Valuing option, existence, and bequest demands for wilderness. Land Economics 60. (February 1984).

06.012* CRIS0081176
**CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND
 EFFECTS ON LAND AND SURFACE WATERS**

GIBSON J H; Office of The Director; Colorado
 State University, Fort Collins, **COLORADO**
 80523.

Proj. No.: COL00223 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish Atmospheric Deposition
 Network to determine spatial and temporal
 trends in supply of beneficial nutrient
 elements and potentially injurious substances
 in precipitation & dry particulate matter.
 Determine relative importance of precipitation
 & dry particulate matter. Develop optimum
 procedures. Determine stability of collection
 or precipitation constituents. Investigate
 transport & transformations. Organize and
 coordinate research in SAES, FS & other
 institutions on the effects of atmospheric
 deposition on the productivity of agricultural
 crops, forests, range, wet lands & surface
 waters.

Approach: A program coordinator's office will
 be maintained to provide support for the NC-141
 regional research project including project
 coordination, travel, special analyses and
 other project activities as needed by the
 regional research project. (This is to cover
 the RRF Off-the-Top Trust Fund to NC-141).

Progress: 82/01 to 82/12. Funds made
 available by the North Central Region of the
 State Agricultural Experiment Station (NC-141)
 and the U.S. Department of Agricultural CSRS
 are combined to support the coordination, data
 management and publications for the
 NC-141-sponsored program in atmospheric
 deposition referred to as the National
 Atmospheric Deposition Program (NADP). This
 support has been primarily directed to the
 establishment and coordination of a national
 atmospheric deposition monitoring network.
 Additional support has been obtained from other
 Federal agencies including BLM, EPA, USGS, USFS
 and NOAA, and a number of sites are supported
 by state agencies and private corporations.
 Since the beginning of the program in 1978,
 this monitoring network has expanded to 108
 operating sites across the country, including
 Alaska and American Samoa. In 1983, NADP will
 become the core of the National Trends Network
 (NTN) which is being established under the
 mandated National Acid Precipitation Assessment
 Plan, with the addition of approximately 40
 monitoring sites anticipated by 1984. Data
 published by the program now includes eight
 volumes covering data from July of 1978 through
 December of 1980. In addition, the monitoring
 data is available on computer tape either from
 the National Resource Ecology Laboratory,
 Colorado State University, or from the
 Environmental Protection Agency Data Management
 System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

06.013* CRIS0100004
**ATMOSPHERIC DEPOSITION IN NATURAL ECOSYSTEMS OF
 THE WESTERN UNITED STATES**

FOX D G; Rocky Mountain Forest and Range
 Experiment Station; Colorado State University,
 Fort Collins, **COLORADO** 80523.

Proj. No.: RM-2153 Project Type: INHOUSE
 Agency ID: FS Period: 01 OCT 84 to 30 SEP 89

Objectives: Create the basic knowledge needed
 to determine aquatic and terrestrial ecosystem
 effects resulting from specifically identified
 air pollution sources.

Approach: The research is sequentially
 structured to provide (1) protocols for
 quantifying physical and chemical environmental
 factors that influence aquatic and terrestrial
 ecosystems, (2) a better understanding of
 atmospheric delivery and ecosystem reception of
 air pollutants, and (3) knowledge of the
 biological effects caused by air pollutants
 introduced into ecosystems.

06.014* CRIS0046521
FOREST METEOROLOGY AND AIR QUALITY

FOX D G; USDA Forest Service, Ft Collins,
COLORADO 80521.

Proj. No.: RM-2110 Project Type: INHOUSE
 Agency ID: FS Period: 13 AUG 80 to 03 OCT 84

Objectives: Develop methodologies that define
 and allow simulation of relationships between
 meteorological processes and forest and
 rangelands and encourage the incorporation of
 this information into land management planning
 activities. Current specific activities include
 outlining strategies for the management of air
 as a renewable natural resource and improving
 planning for the managed use of fire.

Approach: Through meteorological research,
 models and other tools will be developed to
 provide meteorological inputs into fire
 behavior and fire planning models applied to
 mountainous terrain in areas distant from
 weather stations. In addition, a decision
 process incorporating available and refined
 models of probable air pollutant movement,
 deposition and consequences in mountainous
 forests will be developed to aid Federal Land
 Managers in their responsibilities for
 reviewing PSD permit affecting Class I areas.

Progress: 80/08 to 84/09. A unique mountain
 climatology data base has been developed over
 four years with one-per-hour observations of
 meteorological variables on four different
 aspects and at three different elevations on
 Mount San Antonio, NM. Numerous observations of
 wind flows around the mountain have yielded
 information about the relationship between wind
 patterns and atmospheric stability. These data
 have established the validity of statistical
 models of mountain meteorology. Studies on the
 usefulness of meteorological information have
 developed analytical measures of the need for
 and location of meteorological monitoring. A

system of computer models has been developed to aid air resource management decisionmaking. The Topographic Air Pollution Analysis System (TAPAS) includes topography data, two-dimensional and three-dimensional wind simulation models, dispersion models, and visibility impact assessment models. Also, TAPAS modules allow computer generated graphics map overlays (any map scale) of the model results. Utility of the system for operational decisionmaking has been demonstrated in the Bureau of Land Management and the Forest Service. Issues of model validity have been addressed culminating in work aimed at quantifying uncertainty in air quality model predictions. Growing recognition of the nondeterministic nature of the air quality modeling problem has led to better regulatory use of these tools.

Publications: 80/08 to 84/09

- FOX, D.G. 1984. Uncertainty in air quality modeling. Bull. Amer. Meteorol. Soc. 65(1):27-36.
- FURMAN, R.W., HAINES, D.A., and MILLER, D.R. 1984. Meteorology and climatology. In: Handb. of For., K.F. Wenger, editor. John Wiley & Sons, Inc. New York. 3:97-141.
- MURPHY, D.J., BUCHAN, R.M. and FOX, D.G. 1984. Ambient total suspended particulate matter and benzo(a)pyrene concentrations from residential wood combustion in a mountain resort community. Amer. Ind. Hyg. Assoc. J.
- RUNNING, S.W. 1984. Documentation and preliminary validation of H2OTRANS and DAYTRANS, two models for predicting transpiration and water stress in western coniferous forests. USDA Forest Service Res. Pap. RM-252, 45p.
- FOX, D.G. 1983. Part A. U.S. experience with air quality modelling. p. 4-156. In: Procs. of Air Quality Modelling Science and Regulation Workshop. Melbourne, Australia, August 17-18, 1983.

06.015 CRIS0097063
RHIZOSPHERE REGULATION OF HEAVY METAL UPTAKE BY FOREST TREES

SMITH W; School of Forestry & Environm Studies; Yale University, New Haven, CONNECTICUT 06520.
Proj. No.: CONR-8501653 Project Type: CRGD
Agency ID: CRGD Period: 01 SEP 85 to 31 AUG 88

Objectives: Proj 8501653. Establish heavy metal gradients in the soil-root interface region (rhizosphere and rhizoplane) for trees growing in the northern forest by using scanning electron microscopy and electron microprobe analysis. Use rhizosphere microcosms to quantify heavy metal root uptake under conditions of increased (artificial application) heavy metal loading of soil and increased acidification (precipitation simulant) of the rhizosphere surrounding intact roots of mature trees of the northern forest. Collect root exudates of mature trees of the northern forest and specifically determine the qualitative and quantitative characteristics of amino and organic acid

fractions in an effort to estimate the ability of these compounds to reduce or chelate heavy metals and to influence the pH of rhizosphere soil.

Approach: Rhizotrons will be employed in the Hubbard Brook Experimental Forest in NH to culture intact roots of mature red spruce. These roots will be treated with heavy metal amendments. Soil pH will be adjusted. A scanning electron microscope, energy dispersive x-ray analyser and proton-induced x-ray emission will be employed to determine heavy metal localization in the root, rhizosphere soil and in bulk soil.

06.016 CRIS0071183
VERTICILLIUM WILT OF LIRIODENDRON TULIPIFERA

MOREHART A L; Plant Science; University of Delaware, Newark, DELAWARE 19711.
Proj. No.: DEL00709(1)
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 24 AUG 76 to 30 SEP 83

Objectives: Study the epidemiology of Verticillium wilt of Liriodendron tulipifera with particular emphasis on the possible involvement of nematodes.

Approach: The pathogenicity of numerous isolates of Verticillium albo-atrum and V. dahliae will be evaluated on greenhouse-grown yellow-poplar seedlings. A single isolate will be selected from this test group for use in all other studies. Factors affecting the initiation of disease will be studied on seedlings and container-grown saplings under both greenhouse and field conditions. Possible nematode-fungus interaction will be evaluated with Pratylenchus penetrans-Verticillium sp. in a complete factorial design. Other nematode species will be included in later studies depending upon the outcome of field surveys. Nematode populations in the rhizosphere of yellow-poplar trees will be estimated through field surveys. Soil samples will be taken from the rhizosphere of yellow-poplar trees, located in various sites throughout the state. Particular emphasis will be given to yellow-poplar stands which have suffered previous losses due to Verticillium wilt. Trees will be grouped according to diameter class and analysed using the coefficient of occurrences and nematode population.

Progress: 76/08 to 83/09. The etiology and epiphytology of verticillium wilt of yellow-poplar trees was investigated. Verticillium wilt of yellow-poplar in Delaware forest settings was attributed to introduction of the pathogen on diseased nursery stock and afforestation on sites which were cropped to plants susceptible to Verticillium species. Most Verticillium isolates collected from forest soils throughout Delaware were pathogenic to root-wounded yellow-poplar seedlings or saplings. In these same settings, Verticillium was isolated from the roots of symptomatic and asymptomatic yellow-poplar trees one to

85-years-old. The incidence of *Verticillium* species in yellow-poplar rhizospheres was greatly reduced or absent in Coastal Plains soils of pH 4.0 or less in the A horizon. Systemic spread of the pathogen in diseased seedlings or saplings only developed after periods of short-term drought not after periods of flooding or adequate soil moisture. The affect of annually introduced populations of *V. dahliae* and/or *Pratylenchus penetrans* on yellow-popular trees in field plots after four years suggested that *Verticillium* infection was greater in artificially wounded roots than those damaged by nematodes, tree growth reduction was greatest in treatments receiving only nematodes, and that nematode soil populations were greatest in plots highest in *Verticillium* propagules.

Publications: 76/08 to 83/09

- LEVINE, A. 1983. Simulated acid rain effects on the interaction of *Verticillium albo-atrum* and yellow-popular. M.S. Thesis.
SCHULTZ, F. 1981. Studies to assess the contribution of *Pratylenchus penetrans* to *Verticillium* wilt of yellow-popular. M.S. Thesis.

06.017 CRIS0074478
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

RIEKERK H; RIEKERK H; For Res & Conserv; University of Florida, Gainesville, **FLORIDA** 32611.
Proj. No.: FLA-FOR-01880 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establishing an Atmospheric Deposition Network to determine spatial & temporal trends in the supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter deposited in various regions of the U.S. Determining the relative importance & contribution of precipitation, dry particulate matter, aerosols, & gases to the total atmospheric deposition in various states & regions in the U.S. Organizing & coordinating research in the SAES, FS, and other research institutions & agencies on the effects of changes in atmospheric deposition on: The productivity of agricultural crops forest range lands, we lands, & surface waters; the health & productivity of domestic foodanimals, wildlife, & fish & the corrosion of metals, painted surfaces, masonry, & other materials in machinery or structures.

Approach: Wet-dry fall collectors will be installed in flatwoods pine-forest landscapes to receive atmospheric deposition. Important chemicals (N, P, K, Ca, Mg, ect.), pH, conductivity & other parameters will be measured in periodic samples. This nutrient flux will be compared to other in dynamic meteorologic-hydrologic models of nutrient cycling in pine forests.

Progress: 77/10 to 83/09. Atmospheric deposition was monitored for 5 years by a wet/day fall collector at the weather station

of the Bradford Forest Experimental watershed about 50 km northeast of Gainesville, FL. The data shows significantly increasing acidity, of rain water at the rate of 0.2 ptl units per year, mainly associated with increasing sulfate and decreasing potassium levels. The change in rain water ptl had no detectable effect on watershed runoff acidity during the same period.

Publications: 77/10 to 83/09

- RIEKERK, H., TREACY, M.W., and SWINDEL, B.F. 1983. Atmospheric deposition patterns in north central Florida. In "Acid Deposition Causes and Effects", Eds. A. E. S. Green and W. H. Smith, University of Florida, Gainesville.

06.018* CRIS0089958
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

RIEKERK H; GHOLZ H L; CANFIELD D E; Forest Resources & Conservatn; University of Florida, Gainesville, **FLORIDA** 32611.
Proj. No.: FLA-FOR-02321 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America, (Network Research), and to assess the effects of atmospheric deposition on land productivity, animal productivity, and water quality (Effects Research).

Approach: Network Research. Wet/dry fall collection stations in Florida in association with weather stations of ongoing research programs directly benefitting from the atmospheric deposition data. Weekly collection and sample shipment with weather data to, and return of data and synthesis reports from NADP central laboratory. Effects Research. Comparative importance of wet/dry fall on nutrient status of plants, soil and waters (Proj. Stat., A4). Effects wet/dry fall on forest nutrient cycling and forest tree growth (B1, 2). Influence on Al mobility and toxicity to fine tree rootss (B6).

Progress: 83/10 to 84/09. Atmospheric deposition was monitored weekly at the Bradford Forest weather station in north-central Florida from Jan 1978 through Aug 1984. Acidity data from the first five years showed a highly significant drop of 0.2 pH units per year down to pH 4.6. Data from the sixth year initially followed the same trend but a reversal began after the summer of 1983 raising the average pH to about 5.0 during the summer of 1984. Plant nutrient inputs with rainfall during 1983 remained similar to that of the previous year and appeared to be significant for the longterm productivity of the sandy acid-leached pine flatwoods soils.

Publications: 83/10 to 84/09

- RIEKERK, H. and KORHNAK, L.V. 1984. Environmental Effects of Silviculture in Pine Flatwoods. In 'Third Biennial

Silvicultural Research Conference' Atlanta, GA, November 1984: (In press).

06.019*

CRIS0074176

CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE-WATERS

WALKER J T; Plant Pathology; Georgia Agric Expt Station, Experiment, **GEORGIA** 30212.
Proj. No.: GEO01249 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 JAN 83

Objectives: Establishing an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Determining the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to the total atmospheric deposition in various states and regions in the United States. Organizing research in the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters; etc.

Approach: Establish a collector of the wet/dry type (Volchok and Graveson) at an approved collection site and ship samples on scheduled basis to a central analytical laboratory for analysis. Determine the contribution and importance of these depositions to the state and region in terms of agricultural productivity (Agronomic crops) and effects on vegetation (trees, shrubs, or turf) in the rural and urban environments, specifically in terms of diseases and contribution to minor element requirements.

Progress: 77/12 to 83/01. Using the protocol of the NADP guidelines, an Aerochem Metric Precipitation Collector (Model 201) was installed in the Georgia piedmont in October, 1978. A recording rain gauge, wind vane-anemometer, and particulate sampler was operated at the site. Ozone levels were monitored elsewhere. Precipitation samples were analyzed by the Central Analytical Laboratory. Particulates (TSP) were determined on a filter exposed for 24 h every 6 days. The effects of acidified water on a variety of plants under growth chamber, greenhouse, and field conditions were determined. The effect of aqueous solutions at different pHs on subsequent seed germination was studied. Over the 1979-81 period, the highest ionic constituent in rain was sulfate with an average of 2.6-3.5 mg/1/yr. followed by nitrate with 1.0 to 1.3 mg./1. The 3-yr. average for 9 ions in mg/1, was: Ca 0.24, Mg 0.13, K 0.18, Na 0.45, NH(4) 0.33, NO(3) 1.2, Cl 0.46, SO(4) 2.99, PO(4) 0.06. The lowest average pH occurred in the 2nd and 3rd calendar quarter, with values ranging from a low of 4.12 to high of 4.96. Average TSPs for 1979, 1980, and 1981, were 37.2, 38.7, and 46.7 mg./m³, respectively. Ozone averaged 3.6 pphm. Lead averaged .052 to .073 mg./m³ annually. Some plant species and

cvs were injured by acidic mists at pH 1.8, but few plants were affected by pH 2.6 sprays. Grass seed germination was decreased by pH 2.6 solutions, but alfalfa, corn and cucumber were unaffected. Germination of some soybean cvs was reduced at pH 2.6.

Publications: 77/12 to 83/01

NO PUBLICATIONS REPORTED THIS PERIOD.

06.020*

CRIS0046519

FORESTRY WEATHER DATA SYSTEMS

PAUL J T; HAUCK C A; Southern Forest Fire Lab; USDA Forest Service, Macon, **GEORGIA** 31208.
Proj. No.: SE-2112 Project Type: INHOUSE
Agency ID: FS Period: 15 AUG 80 to 15 AUG 85

Objectives: Provide forest managers with access to decision-aiding systems based on current weather data, localized interpreted for forestry practices and develop techniques for accessing and controlling smoke impacts.

Approach: Develop a near real-time localized weather data base using interpolation/site correction techniques. Use 1 above as input to user decision models. Determine the influence of stability on fire, develop and test a low-level stability index. Using satellite, digital radar data and surface observations, develop a model which will estimate rainfall between stations. Develop site specific weighting function as an adjustment for interpolation. Develop management models for smoke management using the weather data base and current knowledge of smoke.

Progress: 82/10 to 83/09. Greater fire spread during unstable weather conditions may be accounted for by modifying manning class by one or more categories, depending on the value of the Turner Stability Class used in smoke management, according to a preliminary test. The Forestry Weather Data System (FWIS) is being implemented on a Georgia Forestry Commission computer and on interim basis until FLIPS becomes available. FWIS will be used to make forestry weather duties and forecasts available to federal, state, and industrial forestry users, as well as a base to drive various user decision model such as fire weather and smoke management. A manuscript describing a dispersion under for multiple fire smoke management has been submitted to the Journal of Applied Meteorology. The first version of a FORTRAN computer program for protecting visibility in the Olympic National Park and adjacent smoke sensitive areas has been implemented; an improved version to incorporate complex wind flow patterns and real time weather data is under development.

Publications: 82/10 to 83/09

LAVDAS, L.G. 1983. Rural Dispersion Climatology of the Contiguous United States In: 76 Annual Meeting of the Air Pollut. Central Assoc. 1983, June 19-24, Atlanta, Ga.
LAVDAS, L.G. 1983. A Sampling of Present and Projected Smoke Management Products. In: 7th Conf. of Fire & Forest Meteorol. Soc. & the

Soc. of American Foresters; April 25-27.
Ft. Collins, CO; Am. Meteorol. Soc.,
Boston, MA; 1983.

06.021 CRISO082983
**EFFECTIVENESS OF ROADSIDE VEGETATION IN
REDUCING AMBIENT LEVELS OF TRAFFIC-GENERATED
PARTICULATES**

AUBERTIN G M; Forestry; Southern Illinois
University, Carbondale, ILLINOIS 62901.
Proj. No.: ILLZ-80-R-015 Project Type: STATE
Agency ID: DCI Period: 01 MAY 80 to 30 DEC 83

Objectives: Determine the type and amount of traffic generated particulates generated as a function of traffic, weather and site conditions. Develop methods and procedures to measure the effectiveness of roadside vegetation to reduce airborne particulates. Determine the type and placement of vegetation that most effectively removes traffic generated particulates.

Approach: The research approach is to measure the types and amounts of particulates generated at roadside and relate these to: The conditions of traffic and weather which create and distribute these particulates; the type and placement of roadside vegetation so as to identify the vegetational plantings that will most reduce airborne, roadside particulates.

Progress: 83/01 to 83/12. Effort has continued on writing up the final reports. Two reports (see below) have been completed. Two additional reports are about two-thirds finished. The summary report is in outline form.

Publications: 83/01 to 83/12

AUBERTIN, G.M. (1983). Environmental Assessment of the Effects of Non-Traditional Controls on Air Quality. Section A: White Pine (*Pinus strobus* L.). Final Report Project 10.094 submitted to IENR 197 pp.

AUBERTIN, G.M. (1983). Environmental Assessment of the Effects of Non-Traditional Controls on Air Quality. Section B: Sassafras (*Sassafras albidum* (Nutt.) Nees). Final Report Project 10.094 submitted to IENR 211 pp.

06.022 CRISO073827
**NUTRIENT INPUTS TO THE FOREST FLOOR IN A
HARDWOOD FOREST ECOSYSTEM**

WEAVER G T; AUBERTIN G M; Forestry; Southern Illinois University, Carbondale, ILLINOIS 62901.

Proj. No.: ILLZ-77-R-012
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 NOV 77 to 31 DEC 83

Objectives: Measure the amounts of incident precipitation and the nutrient concentrations in precipitation; measure the volumes and nutrient concentrations of throughfall and stemflow and determine the seasonal patterns of

each beneath different forest cover types; measure the quantity and describe the seasonal pattern of nutrient inputs by particulates; determine the magnitude of differences, if any, in nutrient fluxes via these pathways between the two watersheds being studied; determine if annual rates of nutrient fluxes via these pathways differ from rates reported for other regions of the U.S.

Approach: Permanent plots utilized in other completed and on-going mineral cycling studies will be used for measuring nutrient inputs and transfers via bulk and sub-canopy precipitation. The number and design of rain gages and field collection intervals will be determined in a preliminary study. Laboratory analysis will be completed within one week or less following collection of field samples.

Progress: 77/11 to 83/12. Bulk atmospheric deposition of Ca++, Mg++, K+, SO(4) and NO(3) - in southern Illinois oak forests varied annually and seasonally during a three year, period. Amounts of all ions were greatest and pH often exceeded 5.5 during summers. Deposition of all ions decreased during winter and pH was between 4.0-4.5. Cations apparently associated with dust generated by intense storms countered high sulfate concentrations and raised pH's during summers. Individual summer storms accounted for up to 35% of the annual deposition of some ions. Lower winter pH's reflect disproportionate decreases in concentrations of cations relative to anions. Ion enrichment occurred as precipitation passed through the forest canopy, especially during growing seasons. Contact with the canopy caused the pH of throughfall to increase by up to 0.5 units. Sources of enriching ion apparently included materials filtered from the atmosphere and leached from plant tissues. This study showed that the nature of vegetation can significantly alter the composition and quantities of materials deposited on the forest floor.

Publications: 77/11 to 83/12

NO PUBLICATIONS REPORTED THIS PERIOD.

06.023* CRISO095963
**ACID PRECIPITATION, AIR POLLUTANTS, AND THE
GROWTH OF FOREST TREES ON THE SHAWNEE NATIONAL
FOREST**

WEAVER G T; MYERS C C; IVERSON L; Forestry; Southern Illinois University, Carbondale, ILLINOIS 62901.

Proj. No.: ILLZ-85-R-001 Project Type: STATE
Agency ID: DCI Period: 01 JUL 85 to 30 JUN 88

Objectives: To determine long-term growth patterns of trees on acid susceptible and non-susceptible forested soils; to statistically segregate confounding biotic and abiotic influences to isolate the likely contribution of acid deposition and other air pollutants to growth decline; measure chemical constituents of selected woody tissue to determine if chemical uptake is correlated with growth analysis and atmospheric deposition patterns.

Approach: Periodic increment of pines and oaks growing on plots with sensitive and non-sensitive soils will be determined by increment cores and stem analysis. Twenty-five 0.04 ha plots for each tree-soil combinations (total 100 plots) will be sampled. Growth data will be corrected for age and correlated with measured soil conditions, pH, CEC, and exchangeable cations. Increment cores will be analyzed for changes in contents of several pollutant-related metals.

06.024 CRISO091824
THE EFFECT OF CONIFERS ON ACID SENSITIVE SOILS

WEAVER G T; UDVIG T; Forestry; Southern Illinois University, Carbondale, ILLINOIS 62901.
Proj. No.: ILLZ-83-R-008 Project Type: STATE
Agency ID: OCI Period: 01 OCT 83 to 30 SEP 86

Objectives: The objective of the study is to determine if conversion of sites with soils sensitive to acidification by acidic deposition from native oak to red pine stands causes measurable changes in soil pH and soluble Al.

Approach: Sites with soils sensitive to acidic deposition selected in central Wisconsin where native oak forests had been converted to red pine 30 or more years earlier. Soils were sampled from 5 pits in each of 10 pine and 10 native oak stands to test the hypothesis that no measurable effects were discernible.

Progress: 84/01 to 84/12. This study was designed to evaluate possible effects of pine conversion on forested soils to acidic deposition. Sites remaining in native oak forests and other converted to red pine approximately 40 years were sampled. Soils were of the Tarr and Plainfield Series, which had not been cultivated for agronomic crops. Both exchangeable Al and Ca varied significantly with stocking levels of oak. Differences in pH of 1-1 1/2 units occurred between soil series but differences between oak and pine within each series were smaller. This may indicate that oaks which absorb large amounts of Ca enhance acidification of poorly buffered soils.

Publications: 84/01 to 84/12
UDVIG, T., WEAVER, G.T. 1984. "Effects of pine conversion on acid sensitive soils" (abstract) ASB Bulletin 31(2): 87-88.

06.025* CRISO030313
MINERAL NUTRITION OF FOREST TREES

MCREE W W; Agronomy; Purdue University, West Lafayette, INDIANA 47907.
Proj. No.: INDO50045 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 68 to 30 SEP 86

Objectives: Quantify the uptake rates interactions of plant nutrients by tree seedlings. Determine the influence of the root environment and physiological condition on

nutrient absorption. Determine foliar nutrient levels useful in diagnosing nutrient shortages in trees. Examine the influence of atmospheric deposition of acids, metals and other materials on release on nutrients by soil weathering. Determine effects of material handling and amendments on tree rooting pattern in reconstructed soils on mineland.

Approach: Utilizing carefully controlled conditions the uptake parameters will be determined for tree species and compared to knowledge available on crops. The applicability of parameters and models developed for crops will be determined for forest trees. Foliar diagnosis and root development will be field oriented and make use of studies established in other projects. Atmospheric deposition will be simulated under laboratory conditions. Rooting studies on reclaimed soils will be adjunct to projects with outside funding.

Progress: 84/01 to 84/12. A study of the nutrient supply in native soils that have become acidified due to acid, mine drainage and/or an overburden of mine refuse was initiated. Soils were collected from a site in Warrick Co. for analyses and the establishment of a greenhouse experiment. The influence of acidic deposition on the nutrient supply of soils at high elevation was initiated. Samples were collected and analyses began on 48 samples from 2 sites in the Mt. Zirkel Wilderness area of Colorado.

Publications: 84/01 to 84/12
MEYERS, L.L. and MCFEE, W.W. 1984. Manganese transformation in southern Indiana coal mine overburden. Agronomy Abstracts. p. 31.

06.026 CRISO090945
STRESS PHYSIOLOGY OF WOODY PLANTS

KIMMERER T W; Forestry; University of Kentucky, Lexington, KENTUCKY 40506.
Proj. No.: KY00631
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 03 AUG 83 to 30 JUN 88

Objectives: To develop a bioassay for plant stress based on emissions of acetaldehyde and ethanol, determine whether induction of ethanol biosynthesis by air pollution stress is unique to woody plants, determine the relationship between ethane production and ethanol biosynthesis, and examine the biochemical mechanisms of aerobic ethanol synthesis in stressed plants.

Approach: Plants will be exposed to SO₂, O₃ and a number of other abiotic and biotic stresses in controlled environment chambers. Ethanol and acetaldehyde emissions, along with ethylene and ethane production, will be assayed by gas chromatography. A number of woody and herbaceous plant species will be tested. A bioassay for plant stress, based on emissions of volatile hydrocarbons, will be developed for woody and herbaceous plants, tested and validated in the field. Enzyme and substrate assays will be used to examine the role of pyruvate in aerobic ethanol synthesis.

Progress: 83/08 to 83/12. Biochemical indicators of environmental stress in woody plants are being developed. The goal is to be able to differentiate among several kinds of stress, e.g. water deficit and ozone stress. Trees exposed to ozone stress produce ethanol and acetaldehyde under aerobic conditions. The key enzymes in acetaldehyde and ethanol biosynthesis, pyruvate decarboxylase (E.C. 4.1.1.1) and alcohol dehydrogenase (E.C. 1.1.1.1) have been isolated from soybean cottonwood leaves by affinity chromatography. Following several kinds of stress, including O(3), drought, spider mite injury and heat shock, alcohol dehydrogenase activity increases in cottonwood but not in soybean. Only following O(3) does cottonwood synthesize ethanol. Alcohol dehydrogenase may have other catalytic roles in woody plants. Under anaerobic conditions, previously stressed trees produce ethanol within 1 hour, while in previously unstressed trees, a lag of 2-4 hours occurs.

Publications: 83/08 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

06.027 CRIS0090671
**PHYSIOLOGY, BIOCHEMISTRY, AND BEHAVIOR OF
ECONOMICALLY IMPORTANT PHYTOPHAGOUS INSECT
SPECIES**

ALFORD A R; Entomology; University of Maine,
Orono, MAINE 04469.
Proj. No.: ME08506 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: Insure physiological synchrony of spruce budworm by identifying growth parameters and behavioral or morphological markers for precise staging of test larvae. Monitor the endocrine events of spruce budworm and blueberry maggot growth, development, and diapause. Examine the host selection processes involved in the chemoreception and ovipositional site selection by adult female spruce budworm moths and blueberry maggot flies, emphasizing the effects of environmental factors.

Approach: Critical head-capsule width and body weights and behavioral or morphological markers (such as changes in body position, coloration, ocelli movement and molting) will be identified in spruce budworm larvae. Juvenile hormone esterase activity will be measured as the conversion of JH acid in the haemolymph. Timing of release of prothoracicotropic hormone and ecdysone will be performed through neck and thoracic-abdominal ligature experiment, respectively. Chemoreceptors involved in the host selection and recognition by the females will be identified and characterized using ablation and electrophysiological techniques. Effects of inter-related physical, chemical and biological factors on their receptivity will be investigated.

Progress: 83/10 to 84/09. The alkaline-dissolved *Bacillus thuringiensis israelensis* (BTI) -endotoxin was injected into the abdomen of *Trichoplusia ni*. In vivo

recordings of activity in the ventral nerve cord indicated that BTI -endotoxin elicited hyperexcitability and then nerve death; these symptoms are similar to those resulting from the organophosphorous compound, methamidophos. The effects of low pH (acid precipitation) on growth and development of the caddisfly *Pycnopsyche guttifer* were examined under laboratory conditions. The most critical life stage was the pupa; over 70% and 60% of pupae exposed to pH 3.5 and 4.5 respectively, failed to develop successfully to adults. Larvae exposed to pH 3.5 and 4.5 suffered significant loss of synchrony in their development and took considerable longer to pupate. Spruce budworm larvae reared under constant temperature (20 C) pupated five to seven days prior to and with less temporal variability than larvae reared under fluctuating temperatures (10 /20 C). There were no observed differences in diurnal molting patterns between the two rearing regimes.

Publications: 83/10 to 84/09
ALFORD, A.R., and SILK, P.J. 1984. Behavioral effects of secondary components of sex pheromone of western spruce budworm (*Choristoneura occidentalis*) Free. *Journal of Chemical Ecology* 10: 265-270.
SILK, P.J., KUENEN, L.P.S., TAN, S.H., ROELOFS, W.L., SANDERS, C.J., and ALFORD, A.R. 1984. Identification of sex pheromone components of the jack pine budworm, *Choristoneura pinus pinus* Freeman. *Journal of Chemical Ecology* 10.
ROE, R.M., CHEUNG, P.Y.K., HAMMOCK, B.D., BUSTER, D., and ALFORD, A.R. 1984. The toxicity and nervous response from *Bacillus thuringiensis israelensis* -endotoxin in mice and insects: evidence for broad-spectrum neurotoxicity.

06.028 CRIS0088502
NORTHERN HARDWOOD MANAGEMENT AND UTILIZATION

MCCORMACK M L JR; OSTROFSKY W; Forest Resources; University of Maine, Orono, MAINE 04469.
Proj. No.: ME42811 Project Type: STATE
Agency ID: SAES Period: 01 OCT 82 to 30 SEP 87

Objectives: Provide information to landowners on silvicultural aspects of hardwood growth with particular emphasis on site relationships, use of herbicides, fertilization and genetics. Complete additional research on harvesting problems related to fuelwood management.

Approach: Complete a problem analysis which will include an emphasis on technology transfer of information known. Design field studies to deal with the silvicultural methods most effective in management of quality northern hardwood species.

Progress: 83/10 to 84/09. A study was established in 1983 to evaluate the use of herbicides with shelterwood cuttings. Herbicides were used to control dense, advance regeneration of beech and sprouting of harvested beech in a northern hardwood stand. Beech saplings accounted for 80% of the advance

hardwood regeneration. Approximately 51% of the overstory basal area was comprised of beech which was highly defective as a result of the beech bark disease. Herbicide treatments of glyphosate or triclopyr, when applied using a mist blower, were effective in reducing advance regeneration by 100% and 93%, respectively. When applied to frills on larger beech which were later harvested, glyphosate reduced the number of stump and root sprouts during the first year by 81%, and triclopyr by 91%. Also in 1983, a study was initiated on the effects of acidic precipitation on the diversity of caulosphere mycoflora of young hardwood trees. Sampling tree bark for microorganisms is done annually. Application of the prescribed precipitation treatments to the study plots is scheduled to begin in May, 1985. A new project was implemented which is designed to 1) assess the efficiency of several new timber harvesting systems when used for partial cuttings of hardwood stands, and 2) assess the impact of such harvesting methods on the quality of the residual stand. Data on operations analyses and on stand damage have been compiled, and is now being analyzed.

Publications: 83/10 to 84/09

- OSTROFSKY, W.D., and BLANCHARD, R.O. 1984. Variation in bark characteristics of American beech (*Fagus grandifolia*). *Can. J. Bot.* 62:1564-1566.
- OSTROFSKY, A., and OSTROFSKY, W.D. 1984. Occurrence of *Kabatina juniperi* on eastern redcedar in Maine. *Plant Disease* 68:351.

06.029* CRIS0083333
EFFECT OF SIMULATED ACID RAIN ON THE GROWTH AND NUTRIENT CONCENTRATION OF THREE SPECIES OF SPRUCE

STRUCHTEMEYER R A; Forest Resources; University of Maine, Orono, MAINE 04469. Proj. No.: ME09802

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 10 NOV 80 to 30 SEP 82

Objectives: Objective is to study the effects of simulated acid rain on the growth and nutrient content of three species of spruce seedlings.

Approach: This will be a greenhouse study. Two soils common to the Big Woods area of Maine will be collected. The soil will be screened, placed in plastic pots planted with six seedlings per pot and then watered with simulated rainfall ranging in pH from 7.0 to 2.0. The seedlings will be grown for 30 weeks at which time they will be harvested. The amount of dry matter produced will be determined. Seedlings will be divided into needles, stems and roots. Tissue, soil and leachate will be analyzed for Ca, Mg, K, Na, P, S and N.

Progress: 80/11 to 82/12. Twenty-four plots were established in spruce-fir stands. These plots were located on somewhat poor (Telos) and poorly drained (Monarda) soils. Both physical and chemical soil properties were studied. Results showed that biomass production was

greatest on the Telos soil. Most of the available nutrients were in the organic mat. Average spruce site index was best correlated with the total nitrogen in the O(2) horizon. Of the soil properties studied, total biomass was best correlated to the acidic variables and the cation exchange capacity in the organic horizons. The data collected from the white spruce plantations showed as suspected that when age is constant, soil factors account for more of the growth differences. While the data for this study are being statistically analyzed, the numbers indicate that drainage and the calcium in the soil and tissue account for much of the growth difference.

Publications: 80/11 to 82/12

- GRISI, B.F. 1982. Relationship of Chemical and Physical Properties of Telos and Monarda Soils to Site Productivity of Even-Age Spruce-Fir Stands. M.S. Thesis, Univ. of Maine, Orono, ME. 90pp.
- DAVID, M.B. and STRUCHTEMEYER, R.A. 1982. Disposal of Sewage Effluent on Forested Land: Effects on Groundwater. *Environ. Tech. Letters*, Vol. 3, p.103-110.
- FERNANDEZ, I.J. and STRUCHTEMEYER, R.A. 1982. The Composition of Equilibrium Soil Solutions from Forest Soil B Horizons. *Life Sci. and Agri. Exp. Sta. Tech. Bul.* 105. p.21.

06.030* CRIS0092504
FOREST SOIL - TREE GROWTH RELATIONSHIPS

FERNANDEZ I J; Plant & Soil Sciences; University of Maine, Orono, MAINE 04469. Proj. No.: ME09803

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 89

Objectives: To continue an investigative program to (a) identify critical soil parameters related to tree growth in Maine forests, and (b) improve our knowledge on the suitability of sampling and measurement techniques for forest soils; to quantify the variability of forest soil properties critical to tree growth in both space and time for important species-soil type combinations in Maine; To develop quantitative information on key forest soil parameters which reflect longrange transport of air pollutants, particularly trace metals such as lead, to permit assessments now and comparisons in the future.

Approach: Both field plots and transects at selected forest sites will be used to obtain samples for analysis. Mineral soil and forest floor samples will be collected by horizon with subsequent chemical analysis for selected parameters. Site quality plots will also be assessed for elemental composition of the vegetation. Intensive sampling will be carried out on several sites in order to calculate the degree of variability encountered on uniform soil types for critical forest soil measurements.

Progress: 83/10 to 84/09. This is a new project which officially began October 1, 1984. Therefore, no work has been completed to date on this research. Preliminary work has been carried out to (a) secure commitments for personnel involved with the soil-site work, and (b) identify regional low elevation and one high elevation commercial spruce-fir forest sites to carry out forest floor trace metal analyses.

Publications: 83/10 to 84/09
NO PUBLICATIONS REPORTED THIS PERIOD.

06.031 CRIS0058000
SOIL - TREE RELATIONSHIPS

STRUCHTEMEYER R A; Plant & Soil Sciences;
University of Maine, Orono, MAINE 04469.
Proj. No.: ME09800

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 JUL 70 to 30 SEP 84

Objectives: Study those physical and chemical soil properties that are related to site quality. Quantify the aspects of soil pH that significantly influence tree growth. Chemically characterize the organic matter accumulations found under forest stands.

Approach: Field measurements are made during the summer of many soil characteristics which are then interpreted in terms of the tree growth that has been produced on these soils. Twenty plots were sampled for the pH study. Growth data are available for these plots. Correlations will be made for the various aspects of pH and tree growth. O1 and O2 horizons will be characterized as to C:N ratios, amount of humic and fluvic acids present and the amount of easily oxidized organic matter present. All data will be analysis of variance, Duncan's Multiple Range Test and stepwise regression where applicable.

Progress: 83/10 to 84/09. Since soil pH is often a significant soil property when predicting site quality for soft woods in Maine, an evaluation was made of the relationships between forest soil acidity and spruce-fir growth on 22 even-aged stands in eastern Maine. Site productivity was found to be best correlated with pH of the O horizon, organic matter content of the mineral horizons and organic phosphorus in the B horizon. Soil horizon pH was consistently related to aluminum variables throughout the profiles. A study was also carried out on the importance of organic matter, particularly the forest floor, in the nutrition of even-aged spruce-fir stands. Results of this study included the findings that properties of the O(1), and O(2) horizons important for site productivity were very different with percent volatile matter in the O(2) horizon the best overall predictor of site. A greenhouse study examined the effects of simulated acid rain on tree seedlings with rain treatment pH values ranging from 2.4 to 5.6. Seedling growth was unaffected except for the pH 2.4 treatments but significant changes in nutrient uptake also occurred at pH 3.2. A field study on soil properties affecting

plantation growth of white spruce was carried out and results are still being assessed. Growth plots were also established in natural stands and in plantations where soils were described by the new taxonomy. Statistical evaluations of soil characteristics showed relatively weak correlations with tree growth.

Publications: 83/10 to 84/09

SWEETLEY, M.E. 1981. Relationship of site index and growth of even-aged spruce-fir stands in northern Maine to chemical properties of the forest floor. M.S. Thesis, Univ. of Maine, Orono, ME 136 pp.

FERNANDEZ, I.J. 1981. An investigation into the acid complex and chemical composition of forest soils with respect to growth and nutrient concentrations of even-aged spruce-fir stands. Ph.D. Thesis, Univ. of Maine, Orono. 138pp.

PELLERIN, T.J. 1982. The effects of simulated acid rain on the growth and nutrient concentration of black spruce (*Picea mariana* Mill.) B.S.P., red spruce (*Picea rubens* Sarg.) and white spruce (*Picea glauca* Moench) Voss. M.S. Thesis.

FERNANDEZ, I.J. and STRUCHTEMEYER, R.A. 1982. The composition of equilibrium soil solutions from forest soil B horizons. Maine Agric. Exp. Sta. Tech. Bull. 105. Orono, ME. 22 pp.

SAVIELLO, T.B. and STRUCHTEMEYER, R.A. 1983. Soil and topographic features that help predict the manageability of sugarloaf mountain. Maine Agric. Exp. Sta. Tech. Bull. 791. Orono, ME. 10pp.

06.032 CRIS0093499
EFFECTS OF GASEOUS AIR POLLUTANTS AND ACIDIC DEPOSITION TREE REPRODUCTION

FEDER W A; College of Food & Natural Res.;
University of Massachusetts, Waltham,
MASSACHUSETTS 02154.

Proj. No.: MAS00581 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 89

Objectives: To study the effect, if any, on in vitro pollen germination and elongation, of low level exposure of pollen of tree species to ozone, sulfur dioxide, and wet fall and dry fall acid deposition. To study the combined effects of several of these pollutants on pollen germination and tube elongation. To examine pollutant effects upon stigmal surface structure and stigmal chemistry. To observe pollen/stigma interactions under various pollutant exposure schemes. To examine seed set as it relates to pollutant exposure.

Approach: Studies will be conducted with white pine, red spruce and gray birch. Pollen will be collected in the field and exposed to various pollutants in laboratory chambers, with ozone from an ozone generating bulb, SO₂ from a calibrated permeation tube, acid deposition as wet fall or dry fall. Pollen will be germinated and grown on a dialysis membrane supported on a fortified agar medium. Exposure to the three pollutants will be made simply, and in various sequences. The chambers will also be used for stigma exposure to determine pollutant effects

on pH, conductivity, and chemical composition of stigmatic fluid. Effects on seed set will utilize forced pistillate twigs exposed to pollutants than hand pollinated. Effects on birch seed set can be determined rapidly; conifer twigs will be grafted on seedlings.

06.033* CRIS0085425
EFFECTS OF FOREST PRACTICES, SOILS AND PRECIPITATION ON WATER RESOURCES IN MASSACHUSETTS

MADER D L; College of Food & Natural Res.; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00043

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Assess effects of watershed characteristics, forest cover treatments and precipitation on streamflow. Establish criteria for water quality levels in relatively undisturbed watersheds. Develop computer models to predict effects of treatment alternatives on water yield.

Approach: Continuation of research on streamflow initiated under MS-2 using five stream-gauging stations established on Cadwell creek in Cadwell Research Forest. Weekly water samples for complete chemical analysis. The Brook Watershed Model compared with Cadwell computer Model.

Progress: 83/10 to 84/09. Analysis of low density white pine study plots established in 1962 was completed, including volume and basal area growth, and economic analyses. Results demonstrate the soundness of this management option for plantations on watersheds. Low density plots exhibited much larger sizes and quality of stems after 20 years, much earlier merchantability, and very high board foot volumes. Economic analysis indicated substantial benefits in terms of timber values from the treatments, augmenting early gains in reduced transpiration. Stream-flow and water quality monitoring of the Cadwell Creek Watershed were continued in conjunction with the acid deposition (NADP) monitoring program. The data contributes to the national and state acid rain studies. A paper on stream water condition in relation to acid deposition has been submitted for publication. A study of chemical properties of rainfall and throughfall in sugar maple stands on several soils, to examine canopy/rainfall interactions is near completion.

Publications: 83/10 to 84/09

STONE, R. J. 1984. Low density white pine management. M.S. Thesis, University of Mass., Amherst.

06.034 CRIS0082896
SULFUR DIOXIDE AND ACID RAIN: COMPARATIVE UPTAKE AND NEUTRALIZATION OF SULFUR POLLUTION BY PLANTS

CRAKER L E; Plant & Soil Sciences; University of Massachusetts, Amherst, MASSACHUSETTS 01003.

Proj. No.: MAS00499 Project Type: HATCH
 Agency ID: CSRS Period: 01 NOV 80 to 30 SEP 86

Objectives: Examine and quantify the effectiveness of plants in the uptake and neutralization of sulfur pollution. compare the two major forms of atmospheric sulfur pollution (SO₂) and acidic rain) for their relative hazard to the plants.

Approach: The individual and collective response(s) of plants will be examined following exposure to sulfur pollution as SO₂ or sulfuric acid rain. Initial studies are selectively short term and designed to determine the contribution of plants to the absorption and neutralization of SO₂ and acid rain plus evaluate the acute injury to plants caused by SO₂ and acid rain. Longer term studies will be used to investigate the cumulative response of model plant populations to SO₂ and to simulated acid rain.

Progress: 83/10 to 84/09. The susceptibility of plants to sulfur containing acid rain, sulfur dioxide, and combinations of acid rain and sulfur dioxide have been evaluated. Simulated pollution episodes have been studied with corn, Zea mays. Uptake and absorption of sulfur into plant tissue is greatest under high sulfur dioxide concentrations and low pH acid rains. More sulfur is absorbed from sulfur dioxide than from sulfur containing acid rain when both have equivalent amounts of sulfur. Sulfur containing acid rain may inhibit pollenization and fertilization of corn in the field. An evaluation of acid neutralizing powers of crop leaf tissue demonstrated significant differences among plants. Red Kidney beans and wheat leaves had the greatest buffering capacity.

Publications: 83/10 to 84/09

CRAKER, L.E. and BERNSTEIN, D. 1984. Buffering of acid rain by leaf tissue of selected crop plants. Env. Pollut. (in press).
 SIMON, J.E. 1984. Comparative uptake of sulfur in sulfur dioxide and acid rain by corn. Ph.D. Thesis, Univ. of Massachusetts.

06.035 CRIS0074070
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

MANNING W J; FEDER W A; Plant Pathology; University of Massachusetts, Amherst, MASSACHUSETTS 01003.

Proj. No.: MAS00434 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine

mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors. To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: The separate and combined effects of ozone and sulfur dioxide and acidic deposition on germination, growth, and development of coniferous and deciduous tree seedlings will be determined. Similar studies will involve yield and quality of alfalfa cultivars. Pollen/stigma interactions, in the presence of O(3), SO(2), Pb and Cd will be studied to determine whether reproduction of crop plant and tree species are affected. Effects of O(3), SO(2) and acidic deposition on alfalfa and tree seedling germination, predisposition to seedling diseases and mycorrhizal formation will be studied. Interaction of pollutants and pollen populations will be determined to describe pollutant response diversity between species and cultivars of those species.

Progress: 83/10 to 84/09. Early maturing soybean P.I. 180.499 (susceptible) and P.I. 161.989 (resistant) were selected for their reactions to ambient and controlled foliar ozone injury. A factorial-split plot experiment was conducted to determine the effects of ozone exposure (6 pphm, 6 hrs/day, 5 days/wk), soil infestation with *Fusarium oxysporum* (500 cfu/g soil dw.) and cultivar susceptibility to ozone in plastic greenhouses. Plant dry weights were reduced by ozone 24% with the susceptible line and 11% with the resistant line. Ozone injury was increased by infesting soil with *Fusarium*, but ozone had no apparent effect on root rot. Ozone and *Fusarium* reduced relative growth rate of the susceptible line, and this was due to a lower unit leaf rate and not a lower leaf area ratio. Fourteen alfalfa cultivars were screened for susceptibility to ozone (O(3)). Four-week-old seedlings were exposed to 6-8 pphm O(3) in a greenhouse for 4 weeks, and compared to seedlings grown in a carbon filtered air greenhouse for the same period. O(3) caused a significant depression for both fresh and dry weights for Buffalo, Iroquois, Oneida, Team and Vernal. Apollo II, Honeyoye, Saranac AR and Vanguard were less affected. Dry wt reductions ranged from 0.5% to 69%, and fresh weights were reduced from 8% to 77%. In most cases, a cultivar's visual injury rating correlated with the mean weight reduction. These results suggest that O(3) may decrease alfalfa growth in the Northeast.

Publications: 83/10 to 84/09

- DAMICONE, J.P. 1984. Effects of ozone and *Fusarium oxysporum* alone and in combination on growth of early maturing soybean lines. *Phytopathology* 74:843.
- COOLEY, D.R. and MANNING, W.J. 1984. Differences in alfalfa cultivar

06.036*

CRIS0074071

REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

MANNING W J; FEDER W A; Plant Pathology; University of Massachusetts, Amherst, MASSACHUSETTS 01003.

Proj. No.: MAS00435

Project Type: HATCH

Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors.

Approach: Whole plant responses of tolerant and sensitive cultivate cultivated plants and forest trees will be identified and used to determine responses to ozone and sulfur dioxide. Plant indicators of air pollution will be determined and used to determine air quality through development of dose/response cures. Work will continue on ozone and sulfur dioxide effects on root disease and nodulation of legumes. The effects of elevated heavy metal content of soils on plant sensitivity to pollutants will be determined. Work will begin on acid rain/gaseous air pollutant interactions.

Progress: 83/10 to 84/09. Set up ozone monitoring at Arnold Arboretum, Boston, MA about 10 miles east of Suburban Experiment Station in Waltham, MA. This allowed us to measure air quality on site of the Harvard University, Arboretum large lilac variety collection where leaf roll symptoms have been observed for many years. We could then compare air quality at Waltham and at the Arboretum. Both sites had very similar air quality patterns during summer of 1984. High and prolonged ozone episodes occurred at both sites during late June, early July 1984. Values ranged from 0.1-0.2 ppm for at least 4 hours daily for as long as 3-6 days at a time. Leaf roll symptoms occurred later in the summer at the Arboretum on supposedly ozone-susceptible varieties of lilacs. The degree of injury seemed to relate to ambient ozone levels at the Arboretum. Greenhouse lilacs exposed to schronic low levels (0.06-8ppm) for 5 hrs/day for 5-8 weeks developed flecking and glazing symptoms. Typical leaf roll necrosis symptoms developed on *Syringia vulgaris* cv Marie Legraye, Miss Ellen Wilmot, and Primrose, but only bronzing occurred on cv Congo. This conformed data obtained the previous winter. A complicating factor may be what appears to be feeder root deterioration in the lilacs growing at the Arboretum. I suspect a nematode problem and we will look at this as soon as the ground thaws next spring.

Publications: 83/10 to 84/09

- DAMICONE, J.P., MANNING, W.J. and FEDER, W.A. 1984. Effects of ozone and *Fusarium oxysporum* alone and in combination on growth early maturing soybean lines. *Phytopathol.* 74 (7):843.
- COLLEY, D.R., MANNING, W.J. and FEDER, W.A. 1984. Differences in alfalfa cultivar sensitivity to ozone. *Phytopathol.* 74

(7):843.

06.037* CRISO082978
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS & MATERIALS

FEDER W A; CRAKER L E; Suburban Exper Station; University of Massachusetts, Waltham, MASSACHUSETTS 02154.
 Proj. No.: MAS00496 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils.

Approach: In addition to maintaining 2 NADP/IR7 collection sites, studies of the plant/soil/air rainfall interactions will be made to discover if atmospheric deposition predisposes plants to injury by foliar or root pathogens/pests and if plant injury is enhanced or reduced by inter-actions between atmospheric deposition and other air pollutants like ozone, sulfur dioxide, and/or particulate matter. The effects of changes in soil chemistry from atmospheric depositions upon mycorrhizal and nitrogen fixation organisms will be examined. The changes in soil chemistry due to atmospheric deposition will be studied for their effects on the mobilization of toxic elements like Al and the subsequent effects of released aluminum upon aquatic ecosystems. The movement of trace heavy metals from atmospheric deposition through terrestrial ecosystems will be followed and the effects quantified.

Progress: 83/10 to 84/09. Continued to operate wet/dry collectors for NADP network. Also participated in state-wide survey of aquatic lake/pond/stream pH values and fairly high alkalinity values, indicating little rainfall effect upon pH of aquatic areas surveyed. Soil solution pH rather than rainfall pH controlled movement of heavy metals through two soil types. Agriculturally, soil chemistry and soil solution chemistry will regulate the magnitude of the acid rainfall effect on plants growing in any soil. This seems to confirm the fact that crop plants growing in good agricultural soils properly cared for culturally will not be adversely affected by acid precipitation, per se. It is important to appraise farmers of this information, while at same recognizing that the action of acid rainfall over forest ecosystems may have a different impact, of which to date, we have little understanding. This project will be continued under a new Hatch Project Number, as of October 1, 1984.

Publications: 83/10 to 84/09

MIKA, J. S. and WILLIAM A. F. 1984. The movement of incinerator fly ash and residue-generated Cd, Pb and Zn through soil columns leached with acid precipitation, APCA Northeast Atlantic International Section Technical Meeting.

06.038 CRISO097487
EFFECTS OF AIR POLLUTION ON THE GENETICS OF FOREST ECOSYSTEMS

KARNOSKY D F; School of Forestry and Wood Products; Michigan Technological University, Houghton, MICHIGAN 49931.
 Proj. No.: MICZ027600 Project Type: STATE
 Agency ID: DCI Period: 01 OCT 84 to 30 SEP 89

Objectives: Determine evolutionary effects of air pollution on hardwood forest systems.

Approach: Make random collections of plant material of six eastern hardwood species from forest stands across the U.S. and subject those plants to artificial doses of air pollutants.

06.039* CRISO079282
EFFECTS OF ACID PRECIPITATION ON NUTRIENTS IN MICHIGAN FOREST SOILS

BOYLE J R; School of Natural Resources; University of Michigan, Ann Arbor, MICHIGAN 48109.
 Proj. No.: MICY00048 Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 82

Objectives: Evaluate effects acid rainfall and snowmelt on essential plant nutrients in forest soils of northern Michigan.

Approach: Simulated acid rain will be applied to field plots in three forest sites representing a range of productivity for aspen. Soil percolate will be collected with porous ceramic cup lysimeters. Based on soil chemical analyses and on percolate analyses, evaluation will be made of the effects of acid rain on nutrient mobilization and leaching. Snowmelt lysimeters will be used to collect early-spring snowmelt water for analysis of acidity to evaluate the suspected impact of this short-term, seasonal phenomena on leaching of nutrients.

Progress: 83/01 to 83/05. No progress reported this period.

Publications: 83/01 to 83/05

COFFEY-FLEXNER, D. 1983. Interception and modification of acidic precipitation by bigtooth aspen forest canopies in northern Lower Michigan. M.S. Thesis. Univ. Michigan, Ann Arbor. 207 p.

06.040* CRISO096150
NITROGEN AND MOISTURE RELATIONS IN YOUNG RED PINE STANDS: EFFECTS OF INCREASED NITROGEN AVAILABILITY

RICHTER D D; School of Natural Resources; University of Michigan, Ann Arbor, MICHIGAN 48109.
 Proj. No.: MICY00066 Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 90

Objectives: To evaluate effects of increased nitrogen availability on biotic nitrogen cycling, seedling growth, moisture stress, and pest damage in young red pine (*Pinus resinosa*) stands.

Approach: Greenhouse and field studies will evaluate under controlled nitrogen and moisture regimes, how nitrogen availability affects seedling response to moisture stress. In addition, nitrogen will be added periodically to replicated plots in ten young pine stands (at rates that simulate increased nitrogen inputs in acid deposition) to evaluate the potential for increased atmospheric inputs of nitrogen to alter nitrogen cycling, stand establishment, competing vegetation, and pest damage.

06.041 CRIS0097699
EFFECTS OF ATMOSPHERIC DEPOSITION ON EXCHANGEABLE CATIONS IN FOREST SOILS

RICHTER D D; School of Natural Resources; University of Michigan, Ann Arbor, **MICHIGAN** 48109.
 Proj. No.: MICY-00129-F Project Type: STATE
 Agency ID: DCI Period: 01 AUG 85 to 31 JUL 90

Objectives: To evaluate under laboratory conditions the potential for cation-exchange reactions to moderate decreases of exchangeable nutrient cations in forest soils located in acid-deposition environments.

Approach: Experimentally verify theoretical predictions and computer simulations of soil chemical reactions.

06.042 CRIS0097813
EFFECTS OF NATURAL AND AIRBORNE CHEMICAL STRESSES ON GROWTH AND DEVELOPMENT OF INDIVIDUAL TREES

HDDGES J D; SWITZER G L; Forestry; Mississippi State University, Mississippi State, **MISSISSIPPI** 39762.
 Proj. No.: MIS-0658 Project Type: STATE
 Agency ID: SAES Period: 01 FEB 86 to 01 MAY 87

Objectives: To develop a comprehensive review and synthesis of all available knowledge on the effects of natural and man-caused stresses on the growth and development of individual trees and commercial forests in the southern United States.

Approach: A brief review of the basic physiology and ecology of the major southern tree species and a review and assessment of the methodology associated with quantifying stress effects are included as background for research planning respecting atmospheric deposition in the Southern Commercial Forest Research Program.

06.043 CRIS0091404
INFLUENCE OF SIMULATED ACID PRECIPITATION ON DEVELOPMENT OF LESIONS AT BASE OF PONDEROSA PINE NEEDLE

RICE P M; Botany; University of Montana, Missoula, **MONTANA** 59801.
 Proj. No.: MONZ08406-MS Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 DCT 83 to 30 SEP 84

Objectives: Test association of simulated acid precipitation with basal injury of pine needles. Develop a treatment-response function or a threshold value describing the relationship between pH and the frequency of basal injury. Evaluate the effect of Diazinon AG 500 as a control agent.

Approach: Simulated acid rain will be applied by hand sprayers to 20-year-old ponderosa pine trees, at approximately weekly materials, at four pH levels with an insecticide and four without. Needle retention and frequency of basal injury will be scored and analyzed.

Progress: 83/10 to 84/09. "Basal injury" is pathological lesion that occurs at the base of pine needles. The needle grows from the base where the tissues are relatively thin-walled and uncutinized, although the needle base is partially protected by a fascicular sheath in many pine species. The principal hypothesis for the cause of basal injury is that acidic air and rainfall pollutants deposited on the foliage are carried under the fascicular sheath by precipitation which wets the needle surfaces. Capillary action and subsequent evaporation repeatedly concentrate the pollutants under the fascicular sheath. Once the resistance capacity of the needle surface is exceeded, the pollutants are absorbed into the base of the needle, and the internal cells undergo enlargement, excessive multiplication, and death. This cellular disruption causes tissue swelling and the splitting and collapse of the needle surface. This hypothesis is being tested by controlled spraying of simulated acidic precipitation on the branches of mature ponderosa pines. Four pH levels are being used. A parallel series of treatments include an insecticide; these will be used to evaluate whether insects can cause lesions similar to those believed to be caused by acid deposition. The simulated acid precipitation applications were completed in the summer of 1984. The response of the foliage is being evaluated and the results will be available in the winter of 1984-85.

Publications: 83/10 to 84/09
 ND PUBLICATIONS REPORTED THIS PERIOD.

06.044* CRIS0048883
IMPACT OF FOREST MANAGEMENT AND ACID PRECIPITATION ON NUTRIENTS IN SOIL AND WATER

PIERCE R S; FEDERER C A; HDRNBECK J W; Northeastern Forest Expt Stat, Durham, **NEW HAMPSHIRE** 03824.
 Proj. No.: NE-1652 Project Type: INHDUSE
 Agency ID: FS Period: 07 JUL 83 to 07 JUL 88

Objectives: To evaluate how nutrient cycles in spruce-fir, northern hardwood, and central hardwood ecosystems are affected by forest management practices, acid precipitation, or their combined influences; and to operate the Hubbard Brook Experimental Forest as a Biosphere Reserve.

Approach: Develop means to predict long-term impacts of repeated harvesting and silvicultural practices including selection cutting, strip-cutting, clearcutting, and the severe alteration produced by whole-tree harvesting on soil nutrients and site productivity. Nitrogen mineralization, nitrification, leaching, denitrification, fixation, and plant uptake will be studied in both field and laboratory. Simulation models of the effect of nitrogen stress on long-term forest productivity will be further developed. Quantify the impacts of acid deposition on soil and water chemistry in forest ecosystems through deposition monitoring, measuring concentration of elements in soil solution, quantifying soil vulnerability and studying nutrient availability.

Progress: 83/10 to 84/09. In a comparison of two forms of even-aged management, block clearcutting and progressive strip cutting, the results show: (1) block clearcutting caused water yield increases of 673 mm over 10 years following harvesting, versus 393 mm for strip cutting; (2) with careful logging, soil movement and stream sediment can be minimal on both management types; (3) nutrient leaching of calcium and nitrogen to streams for the 10 year period were 27 kg ha and 22 hg ha respectively for the strip cut watershed whereas the block clearcut losses were 40 kg ha and 59 kg ha respectively. Such losses may not have adverse impacts on soil nutrient capital if harvest intervals are > 70 years. Strip cutting provided a more favorable mix of commercial species (yellow birch and sugar maple) after 10 years. The buffer capacity of forest soils (to buffer acid rain) in ME, NH, and CT was closely related to organic matter, the latter an easy parameter to measure. In spite of this mineral soil in most New England forest soil usually has much larger buffer capacity than organic layers because of the greatest volume. A study of 6 remote ponds in the White Mountains of New Hampshire to observe the susceptibility to acid rain showed that the characteristics of the watershed, including geologic materials, soils, vegetation, soil-water residence time, runoff pathways and land-use, all contribute to the chemistry of the pond. Pond-watershed interactions must be an integral part of any study of pond acidification.

Publications: 83/10 to 84/09

- BUSO, D.C.; MARTIN, C.W.; HORNBECK, J.W.
1984. Potential for acidification of six remote ponds in the White Mountains of New Hampshire. Research Report No. 43. Durham, NH: Water Resources Research Center, University of New Hampshire.
- TRITTON, L.M.; VALENTINE, H.T.; FURNIVAL, G.M. 1983. A new procedure for estimation of tree biomass and nutrient content. In: Mesures de biomasses et des accroissements

forestiers. Orleans (France), 3-7 October 1983. Ed. INRA

06.045

CRIS0093288

INTERACTION OF SPRUCE DEPOSITION AND ROOT DISEASE IN THE DECLINE OF RED SPRUCE

HARRINGTON T C; Botany & Plant Pathology; University of New Hampshire, Durham, NEW HAMPSHIRE 03824.

Proj. No.: NH00300-SProject Type: SPECIAL GRANT
Agency ID: CSRS Period: 01 JUN 84 to 30 SEP 86

Objectives: Compare the microflora colonizing root wounds of red spruce in stands subjected to moderately to highly acidic depositions. Determine the sequence of colonization and significance of the various components of the wound microflora of healthy and declining spruce. Determine the effect of acid depositions on defense reactions of red spruce and on the capacity of root pathogens to invade fresh wounds.

Approach: Fungi will be isolated from artificial and natural wounds at high and low elevations from New York to Maine. Isolation frequencies will be correlated with edaphic factors. Host responses of seedlings and mature spruce to wounding and to inoculation will be compared on healthy vs. stressed trees. Fungi will be isolated at various intervals after wounding. Root growth of seedlings subjected to simulated acid rain will be examined in soils collected at high and low elevations from New York to Maine. Effects of soil and rain chemistry on growth of root pathogens will be examined in vitro. Field inoculations will be made at high and low elevations with and without liming and acidification of soil.

Progress: 84/06 to 84/12. Crown dieback, root damage and mortality of red spruce increased with elevation. An increase in atmospheric depositions (e.g., acid rain, lead, or other metals) or in windspeed with elevation may explain this increase of red spruce decline. Some species of root and butt-fungi were also seen to be more frequent at higher elevations than at lower elevations. Sixty-nine root or butt-rooted spruce or balsam fir trees were sampled at various elevations in the White Mountains. *Resinicium biocolor* was isolated from 18 of these trees, *Hyphoderma tenue* from nine, *Xeromphalia campanella* from nine, an unidentified *Resinicium* sp. from eight, and *Scytinostroma galactinum* from six trees. Each of these root pathogens was restricted to high elevations (above 900 m) or was found more commonly there than at low elevations. *Armillaria mellea*, *Pereniporia subacida*, *Serpula himantoides* and *Polyporus balsameus* were encountered less frequently and were common at low elevation sites than at high elevation sites where red spruce decline is more prevalent. Pathogenicity and the effects of atmospheric depositions on these high-elevation fungi are being examined.

Publications: 84/06 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

06.046 CRIS0089891
**CHEMISTRY OF ATMOSPHERIC DEPOSITION AND EFFECTS
 ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
 MATERIALS**

ECKERT R T; Forest Resources; University of
 New Hampshire, Durham, NEW HAMPSHIRE 03824.
 Proj. No.: NH00288 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of
 atmospheric deposition on the productivity of
 agricultural crops, forest trees, rangeland
 wetlands and soil.

Approach: Two processes will be followed:
 Growth of red spruce (*Picea rubens*) seedlings
 will be evaluated under differing regimes of pH
 and aluminum ion concentrations in the root
 zone including effects on mycorrhizae.
 Observations on seedling roots and shoots will
 include: dry weight biomass, root structure,
 mycorrhizal structure, nitrogen level, aluminum
 level. Samples of wild red spruce will be
 utilized to determine limits of response
 variables; then open pollinated families will
 be assessed for genetic variability in growth
 and response; aeroponic chambers will provide
 controlled conditions for the study. Gene pool
 structure and regeneration in eastern white
 pine relative to airborne oxidants will be
 evaluated using allozyme techniques.

Progress: 84/01 to 84/12. Aluminum effects
 on 3-week red spruce (*Picea rubens* Sarg.)
 seedling uptake of potassium and phosphorus
 under hydroponic conditions were explored.
 Potassium absorption was characterized by
 Michaelis-Menten behavior from potassium
 solutions in the range of 0.01 to 1.0 mM. Above
 1.0 mM, accumulation of potassium was most
 readily accounted for by a linear diffusive
 component superimposed on saturation kinetics.
 Comparison of kinetic parameters revealed an
 increase in V_{max} in roots treated with
 aluminum. Provenance comparison showed two Nova
 Scotia provenances exhibited greater potassium
 uptake capacity than a New Brunswick provenance
 due to a diffusive component operative at high
 external potassium concentrations. Patterns of
 uptake in N.B. material, when exposed to
 aluminum, differed from patterns exhibited by
 N.S. provenances. These results suggest varying
 tolerance to aluminum may exist among
 provenances of red spruce. Phosphorous
 accumulation in eleven-week hydroponic red
 spruce seedlings was increased in roots in the
 presence of aluminum. Translocation of
 phosphorus to apical buds and older foliage was
 reduced in all aluminum treatments to levels
 between 9 and 19 percent of controls. Results
 indicate that presence of aluminum in
 hydroponic culture greatly reduced the amount
 of phosphate available for foliage and apical
 regions.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

06.047 CRIS0076365
**THE COMBINED EFFECT OF SALINE SPRAY AND ACID
 RAIN ON THE FOLIAR UPTAKE OF SODIUM AND
 CHLORIDE**

LEONE I A; Plant Pathology; Cook College, New
 Brunswick, NEW JERSEY 08903.
 Proj. No.: NJ11351

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 07 JUL 83 to 30 SEP 86

Objectives: To determine the effect of
 simulated acidic rain of various pH levels on
 the quantity and quality of epicuticular waxes
 in the foliage of selected conifers and
 deciduous trees; To determine the effects of
 simulated rain of various pH levels on the
 uptake of Na^+ and Cl^- ions from saline spray
 previously, simultaneously, or subsequently
 applied to the foliage of selected conifers and
 deciduous trees; To investigate any change in
 the ratios of K, Ca, or Mg to Na in the foliage
 of trees treated with saline spray and
 simulated an acid rain.

Approach: Representative salt-tolerant and
 sensitive trees will be exposed to simulated
 sea water or run-off from deicing snow, which
 has been found to have an equivalent salt
 concentration, in specially constructed spray
 chambers; to simulated acid rain at varied pH
 levels (2.5 to 5.5); or to a combination of the
 two simultaneously or in sequence. Unsprayed
 trees and trees sprayed with distilled water
 will serve as controls. The leaves will be
 harvested washed by a standardized method to
 remove surface salt accumulations, and analyzed
 for Na, Cl, K, Mg, and Ca content, as well as
 for epicuticular wax content and composition.
 The data will be analyzed by ANOVA and Duncan's
 multiple range test for evidence of any
 interaction between salt spray and acid rain in
 plants.

Progress: 84/01 to 84/12. This report
 contains research results completed during 1984
 for the previous version of this project. There
 is as yet no reportable progress on the revised
 project. Container-grown Norway and sugar
 maples exposed to simulated saline spray during
 winter dormancy made significantly less total
 shoot growth over a 2-year period than did
 similar seedlings not exposed to salt. Leaf
 surface waxes of both salt-sensitive white pine
 and salt-tolerant Japanese black pine increased
 in quantity and in total alkane content as day
 length and temperature levels were increased
 during growth. Japanese black pine waxes had
 significantly greater alkane percentage than
 did waxes of white pine under all conditions.
 The predominance of alkanes in the black pines
 may explain the relative tolerance to foliar
 salt deposits of that species in that alkanes
 render leaf cuticles less penetrable to polar
 salt solutions. Norway maples exposed to runoff
 from a heavily salted highway produced
 significantly narrower growth rings during the
 years 1964-1982 than did similar trees not
 exposed to the runoff. White pines exhibiting
 typical salt toxicity symptoms on the side
 facing a heavily salted road produced
 significantly less shoot growth on the road
 side than did the uninjured shoots on the side
 facing away from the road; indicating that the

injury was probably from aerial salt drift rather than from soil borne salt.

Publications: 84/01 to 84/12

SIMINI, M. and LEONE, I.A. 1984. The role of foliar epicuticular waxes in the tolerance of pine to de-icing salt spray. (Abstr.) *Phytopathology* 74:842.

SIMINI, M. 1984. De-icing salt in New Jersey: its effects on growth; and the role of epicuticular wax as a tolerance mechanism in trees. Ph.D. Thesis. Dept. of Plant Pathology, Rutgers University, New Brunswick, NJ, May, 1984.

06.048 CRIS0096929
**ELEMENT ANALYSIS OF PRECISELY-DATED TREE RINGS
TO STUDY CAUSES OF GROWTH DECLINE**

HALL G S; JACOBY G; Chemistry; Rutgers University, New Brunswick, **NEW JERSEY** 08903.
Proj. No.: NJ-8501650 Project Type: CRG0
Agency ID: CRG0 Period: 30 SEP 85 to 29 SEP 87

Objectives: Proj 8501650. Quantitative multielement analysis of precisely dated tree rings to determine growth decline.

Approach: Tree-rings from the Eastern Network Collection that include 9 different tree species will be analyzed for the elements lithium through uranium using proton induced photon emission (PIPE). The chemical information will be combined with the climatic variables to determine growth response functions. The trace element data will be compared with acid deposition data, if available at the site, to determine if element uptake is effected by acid deposition.

06.049 CRIS0084188
**EASTERN WHITE PINE PROGENY VARIATION IN GROWTH
RATE AND AIR POLLUTION SENSITIVITY**

KUSER J; BRENNAN E; Horticulture & Forestry; Rutgers University, New Brunswick, **NEW JERSEY** 08903.
Proj. No.: NJ12384
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 APR 81 to 31 DEC 85

Objectives: Compare height growth rates, air pollution sensitivities, dates of bud break, and dates of terminal bud formulation of 50 white pine provenances. Determine correlation between growth rate and air pollution sensitivity.

Approach: Fifteen seedlings each of 50 provenances of eastern white pine will be tested. Annual leader growth and 1-, 2-, 5-, and 10-years total heights will be measured. Dates of bud break, dates of terminal bud formation and type, amount, severity, and location of air pollution injury will be noted. 1-, 2-, 5-, and 10-year results will be reported.

Progress: 84/01 to 84/12. Identify seed sources which produce the fastest-growing, least air-pollution-sensitive trees under New Jersey conditions. Seedlings of 74 sources were planted at the Horticulture farm in 1981, 1982, and 1983. At the ends of the 1982 and 1983 growing seasons we found highly significant differences between families in current season's growth, total height, and dates of beginnings and ending growth. Growth ranks remained relatively stable. 1984 data are currently being analyzed. In 1983 the trees were rated for their response to ambient ozone pollution, and they fell into categories that were characterized as sensitive, intermediate, or tolerant. In 1984 the ratings for visible ozone injury were generally consistent with those made in 1983. The tolerant trees were found to have a lower electrical resistance than the sensitive trees when tested with a Shigometer, and this would be indicative of greater vitality. They also tended to be taller than their sensitive counterparts and contain a greater chlorophyll concentration in the needles. Stomatal resistance of the needles was measured with a Li-Cor porometer but the data has not yet been analyzed. In 1984 six progeny representative of each category were included in an experiment in which one-half of the trees was treated weekly with an antioxidant drench (500 ppm EDU) and the other half with water as a control. The antioxidant reduced the amount of injury to the needles.

Publications: 84/01 to 84/12

KUSER, J.E. and HOBBS, B.K. 1984. Second-field-year growth of eastern white pine progenies from seed orchards. *Tree Planters' Notes* 35 (1), 25-29.

KUSER, J.E. and HOBBS, B.K. (in press for Spring '85). Comparative height growth of white pine seedlings from 63 seed sources. *The Bulletin, NJ Acad. of Sci.*

06.050 CRIS0084890
**RESPONSE OF SENSITIVE URBAN TREES TO AMBIENT
AIR POLLUTION IN NORTHEAST**

BRENNAN E; Plant Pathology; Rutgers University, New Brunswick, **NEW JERSEY** 08903.
Proj. No.: NJ11353
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 87

Objectives: To investigate those factors that may be critical in determining the response of sensitive urban tree species to ambient air pollution in Northeastern United States. To determine the impact of ozone pollution on field-grown Eastern white pine trees of varied genotypes and identify characteristics associated with the sensitive/resistant O(3)-response. To determine the effect of acidic precipitation on wound healing in sugar maple, a species currently experiencing a decline in the Northeast.

Approach: A collection of 1200 white pine seedlings (representing 74 seed sources) that was established at Cook College in 1981 will be evaluated for 3 years for ozone injury resulting from ambient pollution. Part of the

population will be treated with an antioxidant (EDU) in order to provide O(3)-free control plants. The injury index will be examined in respect to seed source of the tree, growth rate, vitality, and stomatal strategy. In the acid rain experiments, bark wounds will be inflicted on sugar maple seedlings at varying times during the growing season and exposed to simulated rain at pH 3.5, 4.0, or 5.6. Some of the seedlings will be water-stressed at the time of treatment. The rate of callus formation will be used as a measure of the wound healing response.

Progress: 84/01 to 84/12. White ash seedlings were evaluated for acid rain and ozone response in ambient air in New Brunswick, New Jersey. A plastic covered A-frame shielding seedlings during rain events served as a "rain control" and weekly applications of an antioxidant to the soil of the seedlings served as an "ozone control". During 1984 no visible lesions due to rain or ozone appeared on the foliage. Neither rain or ozone affected the following growth parameters: shoot height or foliar chlorophyll content which was measured weekly or the total leaf area or dry weight of twigs, leaves, and shoots which was measured in late September. The O(3) concentration in ambient air exceeded 0.12 ppm during 25 hours in 1984. The pH of rainfall was 4.2, and the volume of rain was 220% of normal during July.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

06.051 CRIS0004362 INJURY TO VEGETATION BY AIR POLLUTANTS

LEONE I A; BRENNAN E; Plant Pathology; Rutgers University, New Brunswick, NEW JERSEY 08903.
Proj. No.: NJ11150 Project Type: HATCH
Agency ID: CSRS Period: 26 NOV 84 to 30 SEP 89

Objectives: Causes for winter spot will be studied. Effectiveness of a mycorrhizal fungus in adapting Scots pine to simulated landfill gas (CO(2)/CH(4) mixture) will be investigated. Surveys of air pollution injury to crops and woody vegetation in New Jersey, especially with respect to SO(2) injury will be continued.

Approach: Trees with high sensitivity or tolerance to winter spot will be used and examined to determine that they are free of systems. Microbial flora on susceptible and resistant tree will be assayed. Routine observations of needles will be made to determine precisely when lesions appear. Results will be correlated with temperature, rainfall volume and pH of rain. Scots pine seedlings inoculated with *Pisolithus tinctorius* and controls will be allowed to grow in greenhouse until mycorrhizal relation is developed. Then inoculated and noninoculated seedlings will be treated with and without landfill gas (CO₂/CH₄/O₂/N₂ for 3-4 months in hydroponic system. At harvest several parameters will be measured. Data will be analyzed to find fungal effect on seedling growth.

Progress: 84/01 to 84/12. Five honeylocust cultivars were evaluated for tolerance to O(3) pollution over a 3-year period. Symptom development was monitored on a monthly basis during the growing season and changes in diameter growth measured once each year. Measurements of diffusive resistance and transpiration were used to determine if cultivar differences in O(3)-tolerance were associated with differences in gas exchange rates through the stomates. 'Imperial' was the most O(3) sensitive and 'Majestic' the most O(3) resistant cultivar based on foliar response. The average yearly increase in diameter was greatest in the cultivars more resistant to O(3). Ozone sensitivity was negatively correlated with leaf diffusive resistance and positively correlated with transpiration rate. When making cultivar selections for urban tree plantings on the basis of O(3)-tolerance 'Majestic' should be considered first, followed by 'Sunburst,' 'Skyline,' and 'Shademaster.' 'Imperial' should not be used in polluted environments. In the Spring of 1984 we were again aware of discrete light tan or white lesions on the needles of conifers which was identified as the "winter spot" observed on conifers since 1970. We are now in the process of enclosing certain branches of susceptible trees in plastic bags over the winter months to provide symptomatic and asymptomatic material for further study at the end of this current winter.

Publications: 84/01 to 84/12

- LEONE, I. and BRENNAN, E. 1984. TE effects division environmental report in J. of the A.P. Control Assoc. 34:600, 1085.
- LEONE, I.A. 1984. Effects of gaseous air pollution in agriculture and horticulture. 1982. M. H. Unsworth and D. P. Ormrod, eds. Book Review. Soil Sci. 137:469.
- LEONE, I.A. 1984. Fluoride emissions: their monitoring and effects on vegetation and eco-systems. Ed. F. Murray. Book Review. J. Environ. Qual. 13:331.
- LEONE, I. A. and FLOWER, F.B. 1984. Soil characteristics of landfill cover soils in nine U.S. climatological regions. Paper presented at the Third Thematic Conference: Remote Sensing for Exploration Geology. Colorado Springs.
- SMITH, G.C. and BRENNAN, E.G. 1984. Response of honeylocust cultivars to air pollution stress in an urban environment. J. of Arbor. 10:289-293.

06.052 CRIS0074268 REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

LEONE I A; BRENNAN E; Plant Pathology; Rutgers University, New Brunswick, NEW JERSEY 08903.
Proj. No.: NJ11250 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors. To develop methods and

materials to ameliorate the effects of air pollutants on plants.

Approach: Field grown potatoes and soybeans will be treated with antioxidant (EDU) at specified growth stages and foliar injury and crop yields related to those of untreated plants and to the prevailing ozone dosages. Test trees will be exposed to saline spray under controlled land ambient conditions and relationships determined between Na⁺ or Cl⁻ uptake and epicuticular wax quantity and quality. Tree and crop species will be screened through EDU and open-top field chamber techniques to identify resistant cultivars.

Progress: 84/01 to 84/12. An on-going field experiment to assess the impact of oxidant pollution on Williams and Cutler soybean cultivars through the use of the anti-oxidant IDU was repeated in 1984. IDU treatments were made weekly. Although the data have not yet been analyzed statistically, there appear to be no differences between yields in IDU-treated and untreated plots. Five other soybean cultivars: Beeson, Asgrow 3127, MS250, Della, Century, and Elf were also included in the test to compare their foliar symptoms and yields with Williams and Cutler. Conditions were generally more favorable for soybean production in 1984 than in either of the 2 previous years. Five replicates of 3-year-old seedlings of *Pinus thunbergii* and *Pinus strobus* were grown at ambient conditions and at three temperature (10C, 21C, 32C) and photoperiod (8h, 12h, 16h) regimes. Foliar epicuticular waxes were extracted and analyzed for alkane content using temperature-programmed gas chromatography. Foliar epicuticular wax from the salt-tolerant *Pinus thunbergii* seedling had significantly more alkanes than did the wax from the salt-sensitive *Pinus strobus* seedlings. The alkane content increased in both species as the temperature and photoperiod were increased. Greater alkane concentrations in the waxes of the tolerant *Pinus thunbergii* and in the waxes of both species at the higher temperatures and photoperiods make the waxes less permeable to polar solution.

Publications: 84/01 to 84/12

CLARKE, B.B., BRENNAN, E., and REBBECK, J. 1984. EDU: A tool for assessing crop loss due to ambient oxidants. *Phytopathology* (Abstr) 74:843.

SIMINI, M. and LEONE, I.A. 1984. The role of foliar epicuticular waxes in the tolerance of pines to de-icing salt spray. *Phytopathology* (Abstr) 74:842.

06.053 CRIS0084895
THE INFLUENCE OF LEAF STRUCTURE ON HERBIVORY AND NUTRIENT LOSSES

CHABOT B F; Ecology and Systematics Sec;
Cornell University, Ithaca, NEW YORK 14853.
Proj. No.: NYC-183562

Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 10 AUG 81 to 30 SEP 85

Objectives: Analyze how specific aspects of leaf structure affect susceptibility to herbivore damage. We will test alternative hypotheses that damage in a range of species is primarily related to either leaf toughness, phenolic content, or nitrogen content. Toughness will be measured by puncture resistance, but specific components of toughness (fiber, vein density, etc.) will be quantified. Analyze how specific aspects of leaf structure affect rate of nutrient leaching. The relationship between nutrient leaching, leaf toughness, cuticle and epidermal structure, and nutrient content will be examined. The influence of rainfall pH on leaching in different leaf types will be studied.

Approach: Leaf toughness will be measured by force needed to puncture the leaf. Structure will be quantified using stereological procedures on leaf cross section along with chemical analysis of cellulose, hemicellulose, cutin, lignin, polyphenols and nitrogen. Herbivory will be monitored in the field by leaf area missing and in the lab by feeding experiments with generalist herbivores. Nutrient leaching will be followed by conductivity change in water used to soak leaves of different species.

Progress: 84/01 to 84/12. Three projects were conducted with the overall goal of understanding the relationship between leaf structure and loss of nutrients to leaching or herbivores. Black spruce (*Picea mariana*) needles were prepared for light, transmission, and scanning electron microscopy. The structure of epidermal walls, cuticle, guard cells, subsidiary cells, and the nature of cell-to-cell contact, wall composition, and patterns of thickening have been described. The relationship between leaf structure and herbivores was studied in a system using maples and larval Lepidoptera. Leaf anatomy of five species of maples (*Acer negundo*, *A. pensylvanicum*, *A. rubrum*, *A. saccharum*, and *A. spicatum*) was studied and quantified. Leaf texture was quantified using a penetrometer probe and specific leaf weight was recorded. On the basis of anatomical differences, feeding trials were set up. The feeding behavior of two geometrids (*Xanthotype sospeta*, *Campaea perlata*) and three arctiids (*Isia isabella*, *Halisidota tessellaris*, *Spilosoma virginica*) was studied on *A. saccharum* and *A. negundo*, the two most different leaves. Complex, specific relations were found in the behavior and success of each caterpillar species on the maples. Of importance were vein and epidermal structure. The relationship between conductivity, a method often used for evaluation of leaching of plants, and cell structure was studied in a technical project testing the usefulness of tannic acid as a probe for membrane damage.

Publications: 84/01 to 84/12

CHABOT, J.F. and LEOPOLD, A.C. Chilling injury and cell structure in soybean seed radicles: the use of tannic acid as a probe of membrane integrity. *Am. J. Bot.* In press.

06.054* CRIS0096658
ACIDIC DEPOSITION AND MOLYBDENUM AVAILABILITY
IN FOREST SOILS: IMPLICATIONS FOR FOREST
PRODUCTIVITY

HOWARTH R W; Ecology and Systematics Sec;
 Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-183571

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 06 AUG 85 to 30 SEP 88

Objectives: The productivity of northern hardwood forests is limited by nitrogen. Molybdenum is required for nitrogen fixation and for nitrate assimilation by plants and microbes, and so changes in molybdenum availability can affect forest productivity by changing rates of nitrogen cycling in forest soils. This study will quantify the effect of acidic deposition on availability of molybdenum within forest soils.

Approach: We will measure available molybdenum in a variety of forest soils in the Adirondack Mountains, in the White Mountains of New Hampshire, and in the forests of central Maine. Available molybdenum will be measured by anion exchange resin extraction. We will also measure concentrations of molybdenum in leaf tissue from these sites. The effect of changing the acidity of soils on molybdenum availability for each soil type will be determined in laboratory experiments.

06.055* CRIS0089207
WATER AND NUTRIENT FLUXES IN LODGEPOLE PINE
FORESTS IN WYOMING

FAHEY T; KNIGHT D; Natural Resources; Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-147338 Project Type: STATE
 Agency ID: SAES Period: 01 OCT 82 to 30 SEP 85

Objectives: To quantify the rate and mechanism of dry deposition on leaf surfaces. To evaluate the magnitude and pathway of water movement through soil macropores and the role of this process in affecting solute concentrations in subsurface outflow. To characterize organic solutes in ecosystem solutions.

Approach: Field and laboratory methods will be utilized. Dry deposition will be quantified using surrogate surface, branch chambers, and empirical modelling. Macropore flow will be examined by flooding techniques utilizing neutron thermalization and zero-tension lysimetry. Organic solutes will be characterized by standard wet chemistry methods, coalametry, liquid chromatography and gas-liquid chromatography. Results will be integrated for publication in refereed journals.

Progress: 84/01 to 84/12. Currently, we are developing simulation models to predict the effects of environmental variation (soils and meteorology) and natural and human perturbation (forest fire, bark beetle epidemics, clear-cutting) on water and nutrient fluxes in

lodgepole pine ecosystems. These models are being developed using our extensive information base on ten forest stands. Recent simulation analyses indicate that 10% to 30% of snowpack water may be diverted from the streamflow pathway by forest evapotranspiration in spring. Total water outflow may vary by 3 to 4-fold between lodgepole pine ecosystems of different structure. These ecosystems appear to be very well-buffered against acid rain because of abundant acid neutralization capacity in forest floor and soil. Finally, nitrogen loss from these systems (as nitrate) is markedly increased (over 10-fold) during the second and third year following natural and simulated bark beetle epidemics.

Publications: 84/01 to 84/12

FAHEY, T.J., and YOUNG, D.R. 1984. Soil and xylem water potential and soil water content in contrasting *Pinus contorta* ecosystems, southeastern Wyoming, USA. *Decologia* (Berl.) 61:346-351.

PEARSON, J.A., FAHEY, T.J., and KNIGHT, D.H. 1984. Biomass and leaf area in lodgepole pine forests of different structure. *Can. J. For. Res.* 14:259-265.

YAVITT, J.B. and FAHEY, T.J. 1984. An experimental analysis of solution chemistry in a lodgepole pine forest floor. *Oikos* 43:222-234.

06.056 CRIS0072812
THE PHYSIOLOGICAL IMPACT OF FUMIGATING CONIFERS
WITH OZONE AND SULFUR DIOXIDE

LAASSOIE J P; Natural Resources; Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-147556

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 JUN 77 to 30 SEP 82

Objectives: This study will physiologically quantify the effects of ozone and sulfur dioxide on selected conifer species common to New York State. This study is unique and quite timely since it will simultaneously examine: Tree species, physiological activity, concentrations of pollutants below those known to induce visible foliar injury, and pollutants in combination with each other. Pollutant thresholds will be established for each species based on observed reduction in foliar gas exchange rates.

Approach: Physiological activity in response to various pollutant fumigations will be assessed from continuous measurements of seedling net assimilation and transpiration rates. Such gas exchange measurements will be taken using a cuvette/gas analysis/environmental control system made available by the Boyce Thompson Institute, Yonkers, N.Y. Stomatal response will also be examined. Various concentrations of sulfur dioxide and ozone will be used separately and in combination with one another. Optimal light, temperature and water conditions will be used during the fumigations.

Progress: 82/01 to 82/12. During 1982 data analysis and manuscript preparation were completed or nearly completed for a number of

different experiments involving exposure of plants to either ozone or ozone and sulfur dioxide. Due to the large scope and expensive nature of these experiments, funding from this project was combined with others and nonconiferous plant materials were used. Results of the experiments fall within one of two categories; plant growth and yield or leaf physiology/gas exchange. Exposure to low levels of ozone caused linear reductions in growth, dry mass, and yield of hybrid poplar and soybean whether grown indoors or in the field. There were no significant interactions between ozone and sulfur dioxide treatments. Sulfur dioxide exposure had much less effect than ozone and it was estimated that ozone was 300-400% more toxic than a similar dose of concentration of SO₂. Considering the much more widespread occurrence of low level ozone pollution than similar SO₂ pollution we feel that ozone constitutes a much greater threat to productivity of either natural or cultivated vegetation. Exposure to low levels of ozone had a number of effects on leaf physiology and gas exchange. Net photosynthesis of hybrid poplar leaves was increasingly reduced by chronic exposure of aging leaves to ozone. Dark respiration of young leaves was much greater in ozone-treated than control leaves. Leaf chlorophyll contents of aging leaves were lower in ozone-treated than control leaves.

Publications: 82/01 to 82/12

REICH, P.B., AMUNDSON, R.G. and LASSOIE, J.P. 1982. Reduction in soybean yield after exposure to ozone and sulfur dioxide using a linear gradient exposure technique. Water, Air, and Soil Pollution 17:29-36.

06.057* CRIS0091190
EFFECTS OF ACID RAIN ON FOREST ECOSYSTEMS: AN EVALUATION OF CURRENT EVIDENCE

BURGESS R; MANION P; MITCHELL M J; School of Biology Chem & Ecolo; State University of New York, Syracuse, NEW YORK 13210.
Proj. No.: NYZ-2222-01-008 Project Type: STATE Agency ID: DCI Period: 01 JUN 83 to 30 NOV 84

Objectives: To prepare an objective evaluate of current literature on acidic deposition to determine if there is evidence that indicates that there are impacts on forest growth due to that deposition. Included will be an analysis of the extent of the literature pertinent to specific questions raised by the sponsors.

Approach: Literature germane to the effects of acid rain on forest ecosystems will be collected, collated, and categorized. Literature will be categorized three ways: geographic region, ecosystem type, and nature of the document and evaluated from two perspectives: nature and credibility of the data and applicability of the conclusions.

Progress: 83/06 to 84/08. Published literature was extensively surveyed for information on the effects of acidic deposition on forest ecosystems in the northeastern U.S. Over 700 references were located, read, and analyzed for scientific rigor, applicability of

data, methods of sampling, and conclusions drawn. Current evidence is summarized on pollutant emissions and acidic deposition trends, U.S. data are compared with the chemical climate in Germany, and the effects of acidic deposition on forests, aluminum-plant-soil interactions, general forest decline, and dieback in stands of red spruce are discussed. Precipitation chemistry and dendroecological evidence for forest decline were utilized to infer the status of current knowledge concerning acid rain and its potential effects on forest ecosystem growth, productivity, and stability. Major conclusions reached are: 1. There has been dieback of red spruce in the northeastern U.S. in the past 25 years, but the direct, or more probably, cause has not been identified. 2. There is no identifiable threshold concentration of acidic deposition below which it is possible to state that forest ecosystem damage does not occur. 3. None of the mechanisms of alleged impact of acidic deposition on forests can be individually, unequivocally, or directly tied to the dieback of red spruce or other species at this time. 4. Periodic regional drought is strongly implicated in red spruce dieback, but the explicit role of moisture stress in the overall syndrome has been determined.

Publications: 83/06 to 84/08

BURGESS, R.L., DAVID, M.B., MANION, P.D., MITCHELL, M.J., MOHNEN, V.A., RAYNAL, D.J., SCHAEDLE, M. and WHITE, E.H. 1984. Effects of acidic deposition on forest ecosystems in the northeastern United States: An evaluation of current

06.058 CRIS0096268
EFFECTS OF ATMOSPHERIC DEPOSITION ON CANOPY AND SOIL PROCESSES

MITCHELL M J; WHITE E H; RAYNAL D J; School of Biology Chem & Ecolo; State University of New York, Syracuse, NEW YORK 13210.
Proj. No.: NYZ-2533-01-002 Project Type: STATE Agency ID: DCI Period: 28 MAY 85 to 27 MAY 89

Objectives: To project short and long-term effects of atmospheric deposition on nutrient status of a northern hardwood forest ecosystem. To determine whether atmospheric deposition could be causing nutritionally mediated changes in forest productivity. To characterize key processes regulating atmospheric deposition on forest element cycling.

Approach: (Task A) Establish a site at the Huntington Forest in the Adirondack Mountains for intensive sampling of soil chemistry and nutrient cycling. Event sampling of solutions which consist of the preceding dry period and the following wetfall will be taken during the growing season. (Task B) A comprehensive chemical analysis of the vegetation, forest floor, mineral soils and soil solutions will be completed to provide estimates of elemental fluxes in litter and the soil system.

06.059 CRISO093374
RED SPRUCE GROWTH BEHAVIOR IN A DIE-BACK FOREST ON WHITEFACE MOUNTAIN, NEW YORK

RAYNAL D J; KETCHLEDGE E H; WHITE E H; School of Biology Chem & Ecolo; State University of New York, Syracuse, **NEW YORK** 13210.
 Proj. No.: NYZ-2662-01-005

Project Type: SPECIAL GRANT
 Agency ID: CSRS Period: 01 JUN 84 to 31 MAY 86

Objectives: To characterize the nature and progression of Red Spruce die-back syndrome in the Northeastern United States through rigorous statistical analysis of environmental-growth relationships. The study will contribute toward identifying actual causes of the decline, which to date has been attributed mainly to acidic deposition.

Approach: The study will characterize the growth behavior of Red Spruce trees in northeastern high altitude forests and relate this behavior to macroclimate and local stand level determinants of growth. The percent of total variance accounted for by these factors and a growth index of unexplained variance will be determined. It will be assumed that the impacts of atmospheric pollutants are independent of climate and stand variables and are contained within the residuals. Under this assumption, the potential role of atmospheric pollutants in influencing variation of growth will be studied.

Progress: 83/10 to 84/09. Die-back of red spruce (*Picea rubens* Sarg.) in the high altitude forests of the Adirondack Mountains of New York has been documented and cited as a possible result of acidic deposition. While general descriptions of the extent and nature of the die-back syndrome have been made, no detailed quantitative study of individual tree growth patterns has been published. This research uses stem analysis technology to analyze red spruce growth patterns. Rigorous statistical methods are being used to evaluate environment-growth relationships. Trees in three stress classes - recently dead, presently declining, and apparently healthy - were identified for study in late summer 1984 at relatively low and high altitude sites on Whiteface Mountain. Study plots were gridded to enable detailed mapping and stand characterization work. Increment cores have been extracted from potential sample trees to preliminarily evaluate growth behavior. Stand descriptive studies and tree harvesting will be accomplished in early 1985.

Publications: 83/10 to 84/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

06.060 CRISO091191
ALUMINUM BIOGEOCHEMISTRY IN FORESTED WATERSHEDS EXPOSED TO ACIDIC DEPOSITION

RAYNAL D J; SCHAEDEL M; School of Biology Chem & Ecolo; State University of New York, Syracuse, **NEW YORK** 13210.
 Proj. No.: NYZ-2114-01-016 Project Type: STATE
 Agency ID: DCI Period: 06 MAY 83 to 31 DEC 85

Objectives: To test the causal relationship between aluminum toxicity and tree growth reduction and mortality by examining the growth of tree seedlings in solution culture under differing aluminum concentration. To evaluate the Al sensitivity status of the following tree species: red spruce, American beech, sugar maple, white oak, pignut hickory, and loblolly pine.

Approach: Tree seedlings will be cultivated in a solution culture system with added aluminum. Solution and plant tissue analyses will include Al, P, Ca, Mg, and K content.

Progress: 83/05 to 84/08. The objective of this research is to determine the sensitivity of seedlings of honey locust, sugar maple, white oak, American beech, red spruce and loblolly pine to aluminum using solution culture methodology. This effort provides a basis for establishing dose-response curves for aluminum phytotoxicity and identifying toxicity thresholds. Attention has focused on three main tasks: 1) identification and utilization of a reliable method to accurately measure aluminum concentration in micro-quantities of plant tissue, 2) development of nutrient culture techniques for seedling growth, and 3) determination of effects of aluminum on seedling growth and development. Experimental analysis indicates a spectrum of aluminum sensitivity: honey locust is sensitive showing both shoot and root effects at 50-150 μ M Al; sugar maple is intermediate with toxic effects at 1000 to 2000 μ M Al) and loblolly pine is somewhat insensitive at these levels.

Publications: 83/05 to 84/08
 NO PUBLICATIONS REPORTED THIS PERIOD.

06.061* CRISO096269
ACIDIC DEPOSITION AND ADIRONDACK FOREST SOIL FERTILITY: AN APPRAISAL

WHITE E H; RAYNAL D J; MITCHELL M J; School of Forestry; State University of New York, Syracuse, **NEW YORK** 13210.
 Proj. No.: NYZ-2533-20-001 Project Type: STATE
 Agency ID: DCI Period: 12 MAR 85 to 31 DEC 89

Objectives: To test hypothesis on the potentially different impacts of acidic deposition on tree growth for different species and contrasting site conditions.

Approach: (1) Stem analysis techniques will be used to obtain a historical record of annual volume increment and a time series of wood volume produced per unit of cambium of given age and crown position. (2) Multiple regression statistics will be used to determine that portion of growth variation accounted for by climatic variables and age, thus providing information on growth trends related to acidic deposition. (3) Results will be compared for trees thought to represent a range of susceptibility to injury from acidic deposition. (4) Dendrochronological techniques will be used concurrently to establish the relationship between increment core and stem analysis measurements. (5) Tree growth patterns

will be correlated with nutrient levels.

06.062 CRIS0082354
**ACID PRECIPITATION IN AN ADIRONDACK FOREST
 ECOSYSTEM: EFFECTS ON TREE REGENERATION**

RAYNAL D J; Biology; State University of New
 York, Syracuse, **NEW YORK** 13210.
 Proj. No.: NYZ-2226-01-007

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 OCT 80 to 30 SEP 83

Objectives: Characterize the reaction (pH), specific conductance and primary chemical constituents of incident precipitation in the Adirondack mountains. Analyze changing patterns of forest growth and stand development in relation to acid precipitation. Inventory seedlings of commercially important species in second growth and heavily thinned or clear-cut stands to determine influences of acid precipitation on tree regeneration. Determine the influence of simulated acid rain on tree seedlings grown under different soil fertility conditions. Evaluate the sensitivity of forest stand dynamics and forest production to acid precipitation impact.

Approach: Using NADP procedures, weekly precipitation samples and bimonthly dry deposition samples will be collected and analyzed for reaction (pH), specific conductance and chemical constituents. Age and size structural analyses will be conducted from sample plots. Tree seedlings will be tagged in permanent transects in two field sites to determine dynamics of seed germination, seedling emergence and establishment. Seedlings will be exposed to simulate acid precipitation of various pH levels and their performance measured.

Progress: 80/10 to 83/09. Characterization of atmospheric deposition and assessment of the influences of acidic deposition on tree regeneration and growth in Adirondack Mountain forests were the goals of this research project. In conjunction with the National Atmospheric Deposition Program, weekly precipitation samples and bi-monthly dry deposition samples were collected and analyzed to determine major ionic constituents. Monitoring results were summarized in a report in which the patterns of major cation and anion deposition were analyzed. Phenological and demographic studies of tree seedlings were made during 1980-83 in a beech-birch-maple forest to characterize natural regeneration levels. Concomitantly, the influences of simulated acidic precipitation on seed germination and early seedling growth of several deciduous and coniferous trees were determined. Few direct adverse effects of simulated acidic precipitation on tree seed germination or seedling growth were found, although a range of sensitivities between several species was noted. To provide a basis for interpreting possible influences of acidic deposition on tree growth, chronosequences of annual radial and vertical growth and wood volume in

50-year-old plantation-grown red pine, Scots pine and Norway spruce were constructed using stem analysis techniques. This approach promises to yield a characterization of historic tree growth patterns and a context in which to evaluate acidic deposition influences.

Publications: 80/10 to 83/09

RAYNAL, D.J., ROMAN, J.R., and EICHENLAUB, W.M. 1982. Response of tree seedlings to acid precipitation. Effect of substrate acidity on seed germination. Environ. and Expt. Bot. 22:377-384.

RAYNAL, D.J., ROMAN, J.R., and EICHENLAUB, W.M. 1982. Response of tree seedlings to acid precipitation. The effect of simulated canopy throughfall on sugar maple seedling growth. Environ. and Expt. Bot. 22:385-392.

RAYNAL, D.J., and RALEIGH, F.S. 1983. Characterization of atmospheric deposition at Huntington Forest, Adirondack Mountains, New York, 1978-1982. Project report to sponsor, New York State Electric and Gas Corporation.

06.063* CRIS0085604
**MEASUREMENT OF PRECIPITATION AT THE HUNTINGTON
 WILDLIFE FOREST**

RAYNAL D J; Biology Chemistry & Ecology; State University of New York, Syracuse, **NEW YORK** 13210.

Proj. No.: NYZ-2226-01-008 Project Type: STATE
 Agency ID: OCI Period: 06 JUN 80 to 31 MAY 86

Objectives: This project is designed to gather precipitation samples and dry deposition samples in the Central Adirondack Mountains as part of the precipitation monitoring network of the National Atmospheric Deposition Program (NADP). Supporting weather information will also be amassed. The information collected will support the college's efforts determining the actual and potential effects of acid precipitation on certain Adirondack forest ecosystems. The project will also result in an improved basis for evaluating the dynamic nature of precipitation chemistry in the Central Adirondack region.

Approach: Precipitation samples will be collected weekly and dry deposition samples bimonthly on a year-round basis using the Aero-Chem Metrics Model 201 precipitation sampling apparatus. Samples will be analyzed at the Adirondack Ecological Center Laboratory for reaction (pH) and specific conductance. Supporting weather information will be collected daily. All information will be transmitted to the NADP Central Analytic Laboratory (CAL) for further analyses including chemical constituent characterization.

Progress: 83/10 to 84/09. Atmospheric deposition was measured at Huntington Wildlife Forest in the central Adirondack Mountains in cooperation with the National Atmospheric Deposition Program during 1978-1983. Volume-weighted mean pH was 4.18 compared with the NADP lab measured value of 4.34. Annual wet deposition of sulfate measures 23 kg ha while nitrate deposition measures about 14 kg

ha . Major mechanisms for input of ions to hardwood and conifer forests at Huntington Forest were studied. Transport of ions from atmosphere to forest floor were identified using regression analyses and the assumption that deciduous and coniferous forests capture particulate matter and aerosols with differing efficiencies. Impaction of suspended particulates and aerosols was an important source of sulfate and nitrate and these ions may contribute to leaching of calcium from foliage.

Publications: 83/10 to 84/09

MOLLITOR, A.V. and RAYNAL, D.J. 1983. Atmospheric deposition and ionic input in Adirondack Forests. *Journal of the Air Pollution Control Association* 33: 1032-1036.

06.064 CRIS0088238
ROLE OF SULFUR IN AFFECTING NUTRIENT STATUS OF FOREST SYSTEMS

MITCHELL M J; NAKAS J P; WHITE E H; Environ & Forest Biology; State University of New York, Syracuse, NEW YORK 13210.
Proj. No.: NYZ-2226-01-009
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 84

Objectives: To ascertain the role of sulfur dynamics in affecting the nutrient status of forest systems which are subject to acid precipitation.

Approach: Established field sites will be monitored for throughfall and leachate. Water will be sampled by simetry and soil will be sampled for pH, nutrient and sulfur content to determine the major inorganic and organic sulfur fractions in both hardwood and conifer sites.

Progress: 83/10 to 84/09. Sulfur (S) constituents were measured in vegetation, soils, throughfall and soil solutions of hardwood and conifer sites at the Huntington Forest, New York. The flux of S constituents among and within these ecosystem components was also determined. Organic S predominated the forest spodosol and S was closely coupled to carbon and nitrogen. Organic S was found in throughfall and soil solutions of both sites and was dependent of solution organic carbon levels. Most of the total S of the northern hardwood forest was found in the mineral soil (88%) with 5% in the forest floor and 7% in plant biomass. Estimated S mineralization for the ecosystem was greater than measured atmospheric inputs. This suggests that factors influencing mineralization-immobilization processes are important in evaluating S cycling and sulfate flux.

Publications: 83/10 to 84/09

DAVID, M.B., MITCHELL, M.J. and NAKAS, J.P. 1982. Organic and inorganic sulfur constituents of a forest soil and their relationship to microbial activity. *Soil Science Society of America Journal* 46:847-852.

DAVID, M.B., MITCHELL, M.J., and SCHINDLER, S.C. 1984. Dynamics of organic and inorganic sulfur constituents on a hardwood forest soil and their relationship to nutrient cycling. Sixth North American Forest Soils Conference, Knoxville.
LANDERS, D.H., DAVID, M.B., and MITCHELL, M.J. 1983. Analysis of organic and inorganic sulfur constituents in sediments, soils and water. *International Journal of Environmental Analytical Chemistry* 14:245-256.
MORGAN, C. 1984. Role of soil fauna in sulfur fluxes in forest soils. M.S. College of Environmental Science and Forestry, SUNY (in prep.).
SCHINDLER, S.C. 1984. Sulfur transformations and movement in an Adirondack Forest Soil. M.S. College of Environmental Science and Forestry, SUNY, 172 p.

06.065 CRIS0088235
EFFECTS OF ACID PRECIPITATION ON ECTENDOMYCORRHIZAL ASSOCIATIONS IN RED PINE

WANG C J K; WILCOX H E; Environ & Forest Biology; State University of New York, Syracuse, NEW YORK 13210.
Proj. No.: NYZ-2114-01-013
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 85

Objectives: To determine the effects of pH on fungal cultures of ten soil fungi and their colonizing behavior in monoxenic cultures with red pine. To determine the effects of acid precipitation on populations of soil microorganisms in naturally occurring forest soil favorable for red pine and the effect of these altered soil populations on the ability of selected funig to produce mycorrhizal associations.

Approach: Ten soil fungi, saprobic, mycorrhizal, or pathogenic to red pine will be selected. Monoxenic cultures of the fungi will be prepared and adjusted to varying pH with seedlings planted directly inthe substrated. Seedlings and fungi will be examined grossly and anatomically to determine the effects of pH on the total root system morphogenesis and shoot growth.

Progress: 83/10 to 84/09. 1) Two new species of mycorrhizal and one new species of pseudomycorrhizal (pathogenic) fungi are proposed: *Phialophora finlandia* Wang & Wilcox, *Chloridium paucisporum* Wang & Wilcox, and *Phialocephala fortinii* Wang & Wilcox. A study of their associations with red pine, red spruce and yellow birch has clarified some of the confusions in mycorrhizal research concerning the fungus *Mycelium radialis atrovirens*. 2) The effects of pH on mycorrhizal syntheses have been successfully demonstrated in monoxenic cultures of 5 mycorrhizal fungi in red pine, red spruce and yellow birch seedlings. The control seedlings of these three species, i.e. without fungal association, all did poorly at pH 3. The ectendomycorrhizal seedlings of red pine and red spruce at pH 3 were smaller than those at pH 5.7, although they were healthier

than seedlings without mycorrhizae. The ectomycorrhizal seedlings of red pine, red spruce, and yellow birch inoculated with *Cenococcum* all showed the deleterious effect at pH 3 as compared with those at pH 5.7. 3) The experiment demonstrating the effects of simulated acid rain on the mycorrhizae in red pine seedlings in the soil columns has provided insights. The buffering capacity of sandy soil is high enough to prevent a precipitous decline in pH. After six months of treatment with acid rain of pH 3, the pH dropped from the original pH 5.3 to pH 4.8, and after 18 months, to pH 4.5.

Publications: 83/10 to 84/09

YANG, C.S. and WILCOX, H.E. 1984. Technique for observation of mycorrhizal development under monoxenic conditions. *Can J. Bot.* 62:251-154.

YANG, C.S. and WILCOX, H.E. 1984. An E-strain ectendomycorrhiza formed by a new species, *Tricharina mikolae*. *Mycologia* 76:675-684.

YANG, C.S. 1984. The development of ecto- and ectendomycorrhizal of *Pinus resinosa* Ait. and *Pinus taiwanensis* Hay. Ph.D. Thesis. 163 pp. SUNY College of Environmental Science and Forestry, Syracuse, N.Y.

LOBUGLIO, K.F. 1984. Growth and survival of ectomycorrhizal and ectendomycorrhizal seedlings of *Pinus resinosa* Ait. an iron tailings. M.S. Thesis. 105 pp. SUNY College of Environmental Science and Forestry, Syracuse,

06.066 CRIS0088232
IMPACT OF ACIDIC DEPOSITION ON PLANTATION-GROWN CONIFERS USING STEM ANALYSIS

WHITE E H; RAYNAL D J; School of Forestry; State University of New York, Syracuse, NEW YORK 13210.

Proj. No.: NYZ-2226-20-010

Project Type: MCINTIRE-STENNIS

Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 84

Objectives: To determine if stem analysis provides a valid measure of the impact of atmospheric deposition on tree growth and to establish a relationship between increment core analysis and stem analysis for measurement of growth in trees.

Approach: Plantation grown conifer species will be sampled from stands of well known soil nutrient status. Growth parameters related to volume and increment will be measured at various points on the stem. These measurements will be correlated with climatic variables and other environmental measures. By drawing upon extensive stand histories and long-term measures of soil nutrient status previously conducted on this site, hypotheses concerning the impact of acid precipitation on forest growth will be evaluated. TERRESTRIAL-EFFECTS.

Progress: 82/10 to 84/09. Graphical and statistical analysis was completed on 70 trees from which discs were taken from every internode for stem analysis. Species sampled were Norway spruce, red pine and Scots pine. Growth parameters evaluated were height,

diameter, basal area, annual volume and specific volume increment as well as mean annual volume increment, vertical growth profiles and vertical ring width chronosequences. Correlation and regression analysis was used to relate growth patterns to climatic, soils and stand competition factors in an attempt to isolate causal factors responsible for individual tree growth variation. Based upon the data obtained from the sample trees species on two contrasting sites, there is no evidence of a recent decline in growth that is uncorrelated with climatic factors, competition and age.

Publications: 82/10 to 84/09

NO PUBLICATIONS REPORTED THIS PERIOD.

06.067 CRIS0097561
ELEMENT ANALYSIS OF PRECISELY-DATED TREE RINGS TO STUDY CAUSES OF GROWTH DECLINE

JACOBY G C; Tree Ring Laboratory; Manhattan College, Riverdale, NORTH CAROLINA 10471.
Proj. No.: NYR-5-23074 Project Type: CRGO
Agency ID: CRGO Period: 15 SEP 85 to 30 SEP 87

Objectives: PROJECT 8501668. To produce year-by-year time series of chemical concentrations in the environment over the past century, chemicals that may be related to air pollution of acid rain and tree growth changes.

Approach: Accurately dated samples from annual growth rings of trees will be analyzed using proton-induced photon emission (PIPE) which includes PIPE and PIGME. Time series for over two dozen elements between lithium and uranium will be developed and compared statistically with annual growth rates and meteorological variations.

06.068 CRIS0014566
ECOLOGY AND CONTROL OF FOREST TREE DISEASES

GRAND L F; BRUCK R I; Forestry; N Carolina State University, Raleigh, NORTH CAROLINA 27650.

Proj. No.: NC04012

Project Type: MCINTIRE-STENNIS

Agency ID: CSRS Period: 01 DEC 65 to 30 SEP 86

Objectives: To investigate resistance of pine to fusiform rust including evaluation of cloned seedlings under artificial and field situations. To investigate mycorrhizae of important forest tree species including confirmation of suspected mycorrhizal fungi, effects of mycorrhizae on growth and survival in greenhouse and field conditions and effects of management practices and other factors on mycorrhizae. To investigate other forest tree disease as they become important.

Approach: Evaluation of resistance of loblolly pine clones to fusiform rust in greenhouse and field conditions. Identification, confirmation, and role of conifer and hardwood mycorrhizae in

relation to improved survival growth and resistance to root pathogens. Study the effects of nursery practices, such as fumigation and types of mulches, on mycorrhizae formation. Investigate diseases that may pose immediate or new threats to southern forest trees.

Progress: 84/01 to 84/12. Simulated acidified rain at pH levels of 2.4, 3.2, 4.0 and 5.6 (control) (pH adjusted with nitric acid, sulfuric acid or in combination) was applied twice weekly to *Pinus taeda* seedlings grown in containers in a greenhouse for 12 weeks. Fewer ectomycorrhizal tips were formed at pH 4.0 compared to other pH levels for all acid treatments. Fewer ectomycorrhizae tips were formed at pH 4.0 acidified with nitric acid compared to all other pH levels and treatments. Results indicate the nitrogen component of simulated acid rain may be responsible for suppression of ectomycorrhizae. Six morphotypes of ectomycorrhizae of *Abies fraseri* and 8 of *Picea rubens* were identified from 8 permanent plots (N, S, E, W aspects) established at high (greater than 6200 ft.) and low (less than 5200-6000 ft.) elevations on Mt. Mitchell, North Carolina. Plots were established in healthy and declining stands and sampled in late August and September. Quantification of ectomycorrhizae by morphotype from these plots is in progress and will be compared to soil analyses, tree growth parameters and tissue analyses. GRADUATE STUDENTS = 1.

Publications: 84/01 to 84/12

SHAFFER, S. R., GRAND, L. F., BRUCK, R. I. and HEAGLE, A. S. 1985. Formation of ectomycorrhizae on *Pinus taeda* seedlings exposed to simulated acidic rain. *Can. J. For. Res.* Vol. 15. (In Press).

06.069 CRIS0096482 ECOLOGY AND CONTROL OF FOREST TREE DISEASES

GRAND L F; BRUCK R I; Forestry; N Carolina State University, Raleigh, NORTH CAROLINA 27650.

Proj. No.: NC04098

Project Type: MCINTIRE-STENNIS

Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 90

Objectives: Determine effects of acidic precipitation and heavy metals (Pb, Zn, Mn, Cd) on mycorrhizae of forest trees and confirm suspected symbiotic fungi; study rhizosphere organisms, root-infecting fungi and nematodes associated with spruce-fir decline; evaluate tip moth/pitch canker relationship and resistance of loblolly pine to pitch canker; monitor *Phytophthora cinnamomi* (Pc) populations for resistance to metalaxyl; evaluate loblolly pine clones for resistance to fusiform rust.

Approach: Mycorrhizae will be evaluated on fir, spruce, and pine grown in soils with heavy metals and on seedlings receiving various treatments with simulated acidic rain; isolations will be made from roots and rhizospheres of declining fir and spruce and compared with isolations from healthy trees; fir and spruce seedlings will be inoculated

with *Sphaeronema sasserii* to determine pathogenicity, life cycle, and temperature requirements; isolations from all stages of tip moth will be made to determine the presence of *Fusarium moniliforme* v. *subglutinans* and incidence of pitch canker will be correlated with tip moth infestations and loblolly pine families; Pc will be periodically isolated from sites treated with metalaxyl and resistance determined in the laboratory.

06.070 CRIS0082392 EPIDEMIOLOGY OF FOREST TREE DISEASES

BRUCK R I; GRAND L F; Plant Pathology; N Carolina State University, Raleigh, NORTH CAROLINA 27650.

Proj. No.: NC03722

Project Type: HATCH

Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 90

Objectives: Study epidemiology, biometeorology, management and control of forest tree diseases in the southern U.S. Assess acid precipitation effects on forest tree disease complexes, including mycorrhizal symbiosis. Elucidate the mechanisms of action of host/pathogen response to acid rain perturbation. Develop predictive models for loss assessment, disease forecasting, and forest management strategies. Quantify incidence and severity of damage in N.C. tree diseases. Develop guidelines and procedures to minimize losses due to disease in forests and small woodlots.

Approach: Pitch canker and fusiform rust disease complexes of loblolly pine will be employed using microelectronic meteorology and disease monitoring equipment. Boreal montane forest decline in the western N.C. mountains will be studied to elucidate effects of acid rain. Predictive models will be used to organize epidemiological data, assess disease progress, and predict future losses. Computer cartography will be employed to assess incidence and magnitude of forest tree disease losses in commercial forests and small woodlots.

Progress: 84/01 to 84/12. Investigations on the epidemiology and biometeorology of pitch canker (*Fusarium subglutinans*) on loblolly pine were conducted during the 1984 field season. Temporal placing of selective media plates up- and down-wind from infected areas proved to be effective in quantifying local inoculum. Pheromone traps were deployed to trap mature pine tip moths. Tip moth populations were highly correlated to pine tip infection throughout the growing season, indicating a vector and/or wounding relationship between the insect and pathogen. Thiabendazole (Mertect) treatments of field-grown, loblolly pine seedlings and saplings proved highly effective in preventing *Fusarium* infections for up to 8 weeks with treatments at or above 6 oz (formulated)/acre. A project was initiated for the purpose of quantifying the extent and magnitude of forest decline in the red spruce-Fraser fir subalpine zone of the southern Appalachian Mountains. Eight sites

ranging from a northern terminus at Mr. Rogers, VA to a southern terminus of the Joyce Kilmer Wilderness, NC were studied by the establishment of permanent plots. West-facing slopes have a greater incidence of decline and greater ring increment suppression when compared to other aspects. Higher loading of heavy metals in surface soils occurs on west-facing slopes and higher elevations, indicating a possible cloud deposition interaction with the decline syndrome.

Publications: 84/01 to 84/12

BRUCK, R.I. and RUNION, G.B. 1984. Effects of thiabendazole on pitch canker of loblolly pine. Proc. Southwide Forest Disease Workshop 10:39.

RUNION, G.B., BRUCK, R.I., and DAVIS, J.M. 1984. Spore dispersal and tip moth relations of pitch canker on loblolly pine. Proc. Southwide Forest Disease Workshop 10:38.

BRUCK, R.I. 1984. Boreal montane forest decline. Perspectives of a Forest Pathologist. TAPPI Journal 37:159- 63.

BRUCK, R.I., ROBARGE, W.P., REYNOLDS, K.M., REBERTUS, R., PYE, J., and HALEY, K. 1984. Observations of boreal montane decline in the southern Appalachian Mountains--Soil and vegetation studies. U.S., EPA, NAPAP Peer Review Document.

06.071*

CRISO094165

ACIDIC DEPOSITION AND ITS INFLUENCE ON MOBILIZATION OF ALUMINUM IN ACID SOILS

ROBARGE W P; Soil Science; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
Proj. No.: NC03898 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 89

Objectives: Develop and use analytical techniques to assess effects of acidic deposition on soil ecosystems with emphasis on: rate of Al release as a function of acidic input; sources of Al that react rapidly with acidic inputs; and suitability of radioisotopes as tracers for Al reactions in soils.

Approach: Pressure membrane filters will be used to measure rate of Al release as a function of acidic input. Labile and total Al in leachates will be determined with 8-hydroxyquinoline reagent. Ion activities will be calculated using computerized chemical models. A combination of soil titrations at constant pH and extracting solutions will be used to quantify sources of Al that react rapidly with acidic input. Batch equilibrations and leaching studies with radioisotopes of Sc, La and Ga will be used to test their suitability as tracers for Al reactions in soils.

06.072

CRISO100016

ATMOSPHERIC DEPOSITION/VEGETATION SURVEY RD&A PROGRAM

BARNARD J; Southeastern Forest Expt Stn; Research Triangle Institute, Research Triangle, **NORTH CAROLINA** 27709.

Proj. No.: SE-4102 Project Type: INHOUSE
Agency ID: FS Period: 22 MAY 85 to 22 MAY 90

Objectives: Determine current or past relationships between various measurements of forest conditions and atmospheric deposition. Determine long-term trends between forest conditions and atmospheric deposition. Develop a data base to assess the effects of alternative emissions control strategies.

Approach: Forest condition and atmospheric deposition are characterized by a wide array of parameters. Any relationships that may exist between forest condition and atmospheric deposition may vary depending upon which parameters of condition and deposition are compared. The parameters that are to be studied will first be defined and enumerated. Then the survey will be designed to collect data to test statistical relationships between forest conditions and atmospheric deposition. The determination of the forest response mechanism is beyond the scope of this program. Data from the survey will be analyzed to create a data base for predicting future condition-deposition relationships which in turn will be used with results from separate response mechanism research to evaluate emission control strategies.

06.073*

CRISO078945

AIR POLLUTANT IMPACTS ON RADIAL INCREMENT OF FOREST TREES

McCLENAHEN J R; OCHINGER L S; Environmental Studies Lab; Ohio Agric Res and Devlp Center, Wooster, **OHIO** 44691.
Proj. No.: OH000284-SS Project Type: STATE
Agency ID: SAES Period: 08 JAN 79 to 30 NOV 82

Objectives: To determine the applicability of tree-ring analysis techniques to the detection and assessment of air pollutant impacts on radial growth of forest trees; To investigate potential relationships between radial tree increment and air pollutant exposure in airsheds of specific point and area sources.

Approach: Tree-ring chronologies based on ring-width indices will be developed for several tree species in stands growing on sites remote from air pollutant sources. The chronologies will be compared by analysis of variance, correlation analysis, digital filtering, and other procedures used to study effects of environment on ring width variation.

Progress: 79/02 to 82/11. Air monitoring and atmospheric deposition data were used as a partial basis for assessing the relative pollutant dose received by areas in

southeastern Ohio for which *Quercus alba* L. tree-ring chronologies were developed. The chronology of ring-width indices (RWI) for a low-dose area was calibrated with local climate. The resulting regression model was then used to predict RWI for *Q. alba* at three sites exposed to higher pollutant levels. Comparison of the actual RWI at these sites with those predicted on the basis of climate (mean monthly temperature and total monthly precipitation) corresponded poorly during approximately 20-year moving correlation periods beginning after 1920 and also after about 1955. Further, climatic calibrations using chronologies from the three high pollutant exposure sites showed trends of decreasing correlation with actual RWI (i.e., poorer fit) beginning about 1930. This evidence points to a non-climatic influence on white oak growth in this region that corresponds with the growth of steel and chemical industries there.

Publications: 79/02 to 82/11
NO PUBLICATIONS REPORTED THIS PERIOD.

06.074 CRIS0074752
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

HOUSTON D B; Forestry; Ohio Agric Res and Devlp Center, Wooster, OHIO 44691.
Proj. No.: OH000624 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 31 DEC 84

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality; To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors; To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: Tolerant and sensitive clones of eastern white pine (*Pinus strobus*) will be studied to: determine photosynthetic response to ozone and sulfur dioxide; determine differences in needle morphology; screen plants in polluted environments for tolerance.

Progress: 77/10 to 84/12. Studies of biochemical and physiological responses of pollution-tolerant (T) and sensitive (S) *Pinus strobus* clones to low-level fumigations with SO₂(2), O₃(3) and SO₂(2) + O₃(3) were completed. Two-hr fumigations with 5 pphm SO₂(2) depressed apparent photosynthesis (Ps) more in S than in T clones, but the reverse was true for week-long fumigations with SO₂(2) and SO₂(2) + O₃(3). O₃(3) alone depressed Ps in both T and S clones. Peroxidase activity was 63% higher in S than in T controls and 29% higher in S clones over all treatments. Monoterpenes did not discriminate between T and S classes before or after fumigation. Qualitative differences were found in simple and polyphenols between T and S controls, as well as differences in phenolic compound frequencies and patterns in response to fumigation. Gas-liquid chromatography of needle cuticular waxes revealed no qualitative differences between T and S clones, but scanning electron microscopy showed epistomatal

waxes are linearly cracked over the stomates of S clones but not over those of T clones.

Publications: 77/10 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

06.075 CRIS0094615
AIR POLLUTION EFFECTS ON GROWTH OF WHITE PINE IN THE CUYAHOGA VALLEY NATIONAL RECREATION AREA

MCCLLENAHEN J R; BROWN J H; Forestry; Ohio Agric Res and Devlp Center, Wooster, OHIO 44691.
Proj. No.: OH000378-SS Project Type: STATE
Agency ID: SAES Period: 15 SEP 84 to 31 MAR 86

Objectives: To develop reliable soil/site models for predicting height growth of white pine (*Pinus strobus*) under low or innocuous air pollution dose conditions; to use the predictive models to assess potential air pollution impacts on height growth of white pine in the Cuyahoga Valley National Recreation Area (CVNRA).

Approach: Plots will be located in white pine stands having similar combinations of soil and topographic factors in the CVRNA and in analogous areas where the potential for air pollution injury is less likely. Multiple regression analyses will be used to develop predictive models for both areas and these equations will be compared to assess the impact of air pollution on growth.

Progress: 84/09 to 84/12. Pine stands in the Cuyahoga Valley National Recreation Area (CVNRA) have been identified on aerial photographs as potential sites for using soil/site and growth intercept techniques to study the effects of air pollutants on growth of *Pinus strobus*, and initial examination of plots on-the-ground has started. Surveys have also begun to locate stands growing on similar soils and/or topography in areas less affected by air pollutants, with the most likely sites being southwest of the CVNRA in glaciated portions of Ashland and Richland Counties, Ohio. Young *Pinus strobus* stands on the CVNRA have also been located as potential sites for establishment of permanent plots to monitor the long-term effects of air pollutants.

Publications: 84/09 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

06.076* CRIS0089297
SOIL, SURFACE WATER, AND PRECIPITATION ACIDITY AND EFFECTS ON PLANTS, SOILS, AND MICROORGANISMS

WEIDENSAUL T C; DICK W A; TUOVINEN O H; Lab For Environmental Studies; Ohio Agric Res and Devlp Center, Wooster, OHIO 44691.
Proj. No.: OH000332-SS Project Type: STATE
Agency ID: SAES Period: 01 SEP 82 to 31 AUG 85

Objectives: Determine forms and amounts of sulfur volatilization from soil systems as affected by various climatic variables and

natural phenomena in green plants and microorganisms. Evaluate the sulfur budget in terms of intensity and fertilizer application. Compare element leaching responses in forest soils as affected by atmospheric sulfur dioxide and acidified precipitation. Determine forest tree growth responses to air pollutant stresses emphasizing acidified precipitation. Evaluate effects of acid precipitation and gaseous sulfur dioxide on forest tree seedling performance and on the activity of microorganisms. Determine effects of sulfur-oxidizing and-reducing bacteria on changes in the quality of leachate and runoff water. Determine the sulfate and nitrate status of soil in Ohio.

Approach: Studies will be conducted under controlled acidity amendment regimes and gaseous pollutant exposures. Field studies using lysimeters and ambient SO₂ monitoring will evaluate sulfur budgets, transformation, and emissions from agricultural soils. Tree-ring analyses will be used to evaluate atmospheric stresses on forest trees.

Progress: 84/01 to 84/12. Precipitation chemistry monitoring data continue to be collected at two sites in Ohio. Two strains of *Thiobacillus ferrooxidans* were able to tolerate Al³⁺ at 0.25 M concentration. The effects of several sulfoxyanions was investigated with growing cultures of *Nitrobacter winogradskyi*. Complete growth inhibition occurred at fairly low concentrations of persulfate, tetrathionate, dithionite, metabisulfite, and trithionate. Aluminum, Ni, and molybdate ions at 5mM decreased O₂ uptake by *Nitrobacter agilis*. The largest flux of SO₄²⁻ output from lysimeter plots occurred between October and December. Both tillage and S fertilizer addition affected S flux in the soil. Sulfur outputs are greater than can be attributed to wet deposition. In soil columns, Ca, Mg, and K are generally leached first by simulated rain. There is no obvious trend that clearly relates basic cation leaching to treatment acidity. The most acidic rain solutions were not associated with higher amounts of Zn, Mn, Fe, Ca, Mg, Al, K, and Na in the leachate. Cation leaching peaked when soil solution acidity was greatest, suggesting that total acidity is associated with element leaching. Response function analyses are being made for trees studied in the FORAST Project. Core collections have been made for X-ray densitometry determinations. The importance of climatic variables in tree growth is assessed as well as effects due to air pollutants. The influence of acidic rain on the development of Southern Corn Leaf Blight is being studied.

Publications: 84/01 to 84/12

- MORRA, M.J. and DICK, W.A. 1984. Production of thiocysteine (sulfide) in upland amended soils. *Agron. Abstracts*, 1984.
- MCCLLENAHEN, J.R. 1985. Tree-ring response of white oak to climate and air pollution near the Ohio River Valley. *J. Environ. Qual.* (In Press).

06.077

CRIS0097584

ELEMENT ANALYSIS OF TREE RINGS IN RELATION TO SOILS AND ATMOSPHERIC DEPOSITION

MCCLLENAHEN J R; VIMMERSTEDT J P; JENSEN K F; Environmental Studies Lab; Ohio State University, Wooster, OHIO 44691. Proj. No.: OH000395-SS Project Type: STATE Agency ID: SAES Period: 01 JUL 85 to 01 JUL 88

Objectives: Assess the statistical variability of elemental profiles within annual rings and within and among trees on a site; determine the lateral stability of element concentrations over time; determine the effect of changing soil chemistry on element concentrations; assess the sensitivity of element concentrations in tree rings to a sulfur dioxide and atmospheric deposition gradient.

Approach: Cores will be collected from tuliptrees on twenty-year-old fertilizer study plots, stored and prepared for analysis according to established protocol to avoid contamination. The cores will be subjected to PIXE (Proton-Induced X-Ray Emission) analysis for quantifying spatial and temporal changes in selected elements. Similar analyses will be made on archived cores taken prior to fertilization, and results will be compared for evidence of lateral element transport in xylem. Additional cores will be obtained from site analogs across a potential acid deposition gradient in Pennsylvania and changing element concentration patterns in space and time will be examined by a number of multivariate techniques for evidence of a relationship to the deposition gradient.

06.078

CRIS0097601

ACIDIC DEPOSITION HISTORIES USING MULTI-ELEMENTAL TREE RING ANALYSIS

MCCLLENAHEN J R; Forestry; Ohio State University, Columbus, OHIO 43212. Proj. No.: OH000392-SS Project Type: CRGO Agency ID: CRGO Period: 01 SEP 85 to 31 AUG 88

Objectives: PROJ 8501658. Determine the effect of a coal-fired power plant emissions gradient on multi-elemental profiles in tree rings; determine the effect of contrasting soil properties on multi-elemental profiles of trees having a common pollution history and; compare multi-elemental profiles of tree-ring chronologies to ring width responses determined from standard dendroecological analyses.

Approach: Cores will be collected from tuliptree or other suitable species in a stand having contrasting soils types which lies within an urban airshed. A second core collection will be made along a known sulfur dioxide gradient near a coal-fired power plant, but from site analogs. Elemental concentrations will be determined for specific years using Proton-Induced X-Ray Emission (PIXE). Statistical comparisons of xylem element levels within specific years on the two soils will be made to determine effects of inherent soils

differences. Response functions comparing ring width indices to both climate and element concentration will assess interrelationships among these factors. Element levels for different years along the pollution gradient will be compared with sulfur dioxide emissions and historical monitoring data to test the feasibility of detecting and quantifying such a gradient on xylem profiles and to assess the potential for lateral mobility.

06.079 CRIS0095848
ASSESSMENT OF THE NATURE, EXTENT AND CAUSES OF PITCH PINE DECLINE IN THE EAST-CENTRAL STATES

MCCLLENAHEN J R; Lab For Environmental Studies; Ohio State University, Wooster, OHIO 44691.
 Proj. No.: OH000367-SS Project Type: STATE
 Agency ID: SAES Period: 01 MAR 85 to 01 MAR 88

Objectives: To survey the amount and geographical extent of pitch pine dieback and mortality in relation to site and stand characteristics in areas of Ohio, Kentucky and West Virginia and, to conduct detailed ecological studies of pitch pine decline in Southern Ohio and perhaps elsewhere in relation to various environmental and forest community factors.

Approach: Soil, site and vegetation relationships will be studied at 30 to 60 locations throughout the study region using univariate and multivariate techniques. Intensive studies on a subset of selected sites will determine patterns of recent mortality and examine timing and possible climatic and atmospheric deposition relationships using dendroecological methods.

06.080 CRIS0043696
ULTRASTRUCTURAL STUDIES OF NURSERY CROPS, THEIR DISEASES AND INSECT PESTS

KRAUSE C R; Crop Systems Evaluation Res Grasslnd, Soil & Water Res Lab; USDA Agricultural Research Service, Delaware, OHIO 43015.
 Proj. No.: 3606-20030-006-00D
 Project Type: INHOUSE
 Agency ID: ARS Period: 11 MAR 77 to 11 MAR 84

Objectives: Develop techniques to identify nursery crop cultivars. Develop accurate methods for specific diagnosis of air pollution-induced injury to nursery crops. Identify specific etiological disease agents and pests of nursery crops and analyze host-parasite relationships.

Approach: Lab, Greenhouse and field grown nursery crops will be studied using scanning electron (SEM) and transmission electron microscopy (TEM) & energy dispersive x-ray analysis to distinguish unique surface features among crop cultivars, identify and describe

morphological changes caused by exposure to ozone, nitrous oxides, sulfur dioxide, acid rain & salt, develop a procedure to identify the presence of selected disease and insect pests and/or their damages, elucidate Host-parasite relationship that shows promise for increasing our opportunity to improve disease control methods.

Progress: 83/01 to 83/12. A method for rapid transfer of scanning electron microscopic (SEM) Acer rubrum, red maple, that eliminates fixation or temperature artifacts was developed specifically for use in cultivar identification with SEM, a reliable and quick test to separate cultivars of the same species. Secondary morphological structures were found with SEM to enable sexing of Hylurgopinus rufipes, that native elm bark beetle vector of Dutch elm disease (DED). Improved identification methods could lead to a better understanding of bark beetle behavior and the DED cycle. SEM and energy dispersive X-ray analysis were used to detect air pollution injury to red maples grown in areas of high ambient levels. Particles containing Pb, Fe, S, Cl, Zn, Ti, etc., were associated with irregular wax and lesions. Needle surface of SO(2)-tolerant and SO(2)-sensitive clones of Pinus strobus were examined with SEM. Epistomal wax formed a continuous covering over stomata of tolerant clones, but was split longitudinally over the stomata of sensitive clones.

Publications: 83/01 to 83/12
 KRAUSE, C.R. 1983. A sample transfer procedure for SEM. J. Environ. Hort. (2):36-38.
 KRAUSE, C.R. and FINGERHUT, B.A. 1983. Sexing Hylurgopinus rufipes with SEM. Proc. Entomo. Soc. Wash. 85:748-752.
 KRAUSE, C.R. 1983. Detection of air pollution injury to red maples leaves with EDX. SEM-83/III:1493-1497.

06.081 CRIS0021190
EFFECTS OF ATMOSPHERIC DEPOSITION ON FOREST AND TREES IN THE EASTERN UNITED STATES

DOCHINGER L S; JENSEN K F; MCQUATTIE C J; Northeastern Forest Experiment Station; USDA Forest Service, Delaware, OHIO 43015.
 Proj. No.: NE-2208 Project Type: INHOUSE
 Agency ID: FS Period: 16 AUG 84 to 16 AUG 89

Objectives: To assess and quantify the beneficial and injurious effects of atmospheric deposition on forest structure, composition, and function.

Approach: Research will examine all organizational levels within the forest ecosystem stressed by atmospheric deposition. Laboratory and field studies conducted under a range of experimental and natural conditions will assess direct and indirect consequences of acidic deposition and gaseous pollutants, singly and in combination, on forest tree species. Plant responses to ambient concentrations and exposures of SO(2), NO(x), O(3), with simulated and natural acid rain will be examined. Analysis will determine the

metabolic/ultrastructural basis of cellular activity relative to the impacts of atmospheric deposition. Modifying environmental stress and plant growth processes will be considered in assessing the effects of acidity and related anthropogenic pollutants on forest seedlings. Various doses of exposure and kinds of environmentally-controlled chambers will be used to quantify biochemical, physiological, and related growth impacts of air quality regimes. The laboratory responses will be verified under field conditions.

Progress: 83/10 to 84/09. Acid fog may persist around vegetative structures of forest trees. Analysis of cell areas and air spaces in cross-sections from yellow poplar leaves showed that morphological variations are brought on by reductions in for pH. Through leaf area analysis it was found that foliar size also diminished with decrease in pH. Scanning electron microscopy revealed changes in wax deposition morphology over leaf surfaces which was mostly eroded and fused at pH 2.6. Transmission electron microscopy did not show any significant differences in cuticular fine structure at any pH level. Documentation of ultrastructural changes is of major concern in that induced alternations at the cellular level may progressively affect higher organization levels. Net photosynthetic rate and CO₂ compensation point of a hybrid poplar clone exposed to SO₂, O₃ and their combination were measured at 4300 and 7300 lux and for CO₂ concentrations of 300, 500, and 1000 ppm. Net photosynthesis increased with both higher light intensity and CO₂ but was significantly curtailed by SO₂ plus O₃ fumigation. These findings suggest that as net photosynthesis increases with rising CO₂ concentrations any increase in biomass production could be offset by ambient pollution. Current declines in growth of eastern forests have caused concern that these responses are caused by acid rain and gaseous pollutants. Under field conditions of high inoculum density, SO₂ did not affect etiology of Scleroderris canker of red pine.

Publications: 83/10 to 84/09

- CRANG, R.E.; ROBINSON, S.G.; NOBLE, R.D.; DOCHINGER, L.S. 1983. Acid fog effects on yellow poplar morphology. *Micron* 14:75-76.
DAVIS, D.D.; MILLEN, A.A.; DOCHINGER, L.S., eds. 1984. Proceedings of the symposium: Air pollution and the productivity of the forest; 1983 October 4-5; Washington, D.C. Izaak Walton League of American Endowment. 344p.
JENSEN, K.F.; NOBLE, R.D. 1984. Impact of ozone and sulfur dioxide on net photosynthesis of hybrid poplar cuttings. *Can. J. For. Res.* 14:385-388.
LAURENCE, J.A.; REYNOLDS, K.L.; MACLEAN, D.C.; HUDLER, G.W.; DOCHINGER, L. 1983. Effects of sulfur dioxide on infection of red pine by *Gremmenella abretina*. In: Manion, Paul D., ed. *Scleroderris canker of conifers*.

06.082

CRIS0047991

COMBINED CYCLE BIOMASS ENERGY RESEARCH

THRESHER R W; REISTAD G M; RESCH H; Energy Research & Dev Inst; Oregon State University, Corvallis, OREGON 97331.
Proj. No.: 7006-20195-001-G Project Type: GRANT
Agency ID: ARS Period: 29 SEP 82 to 31 MAR 85

Objectives: Determine the optimum method of burning biomass materials in a thermodynamically efficient and environmentally sound manner to produce electricity. The feasibility of a 10 megawatt directly fired combined cycle power plant utilizing forest slash and agricultural residues will be determined.

Approach: The baseline plant will be analyzed to determine thermal efficiency, mechanical reliability, resource availability, air emissions, engineering constructability, financial and economic viability, and safety requirements. Various design trade-offs will be considered and analyzed to evaluate the potential of changes to the baseline concept. These alternate concepts will be analyzed in order to determine the plant design with the greatest overall viability, considering the available fuel sources, commercially available components, and the real world market for electrical energy.

06.083*

CRIS0022524

FOREST AMENITIES & MUNICIPAL WATERSHEDS

HALVERSON H G; CORBETT E S; HEISLER G M; Northeastern Forest Experiment Station; Pennsylvania State University, University Park, PENNSYLVANIA 16802.
Proj. No.: NE-1651 Project Type: INHOUSE
Agency ID: FS Period: 12 APR 82 to 12 APR 87

Objectives: To determine the effects of trees and woodlands on residential fuel requirements and noise levels in populated areas; to develop methods for improving water quality in multiple use municipal watersheds subjected to acid precipitation; to determine water and nutrient cycle impacts on urban forest vegetation.

Approach: Energy requirement and sound attenuation studies will deal with wind patterns, radiant energy fluxes, and physical principles of sound attenuation as affected by urban forest vegetation. Quality water production under multiple uses on municipal watersheds will involve the effects of forest management prescriptions, human activity, and atmospheric deposition. Water and nutrient cycle impacts on urban and community forests will deal with water stress on urban trees, the impact of atmospheric deposition, and related edaphic effects. Unit research on the effect of forest vegetation on the urban environment will be coordinated with research in the Consortium for Environmental Forestry Studies. This is a multi-functional research work unit.

Progress: 83/10 to 84/09. Trees around buildings may either increase or decrease energy use for heating and cooling depending on tree form and arrangement. In an experiment over most of heating season, the effect of a single-row windbreak on rate of air infiltration and energy use in a small mobile home was evaluated. Air infiltration was reduced by an average of 54% when the windbreak was 1 tree-height from the home. Heating energy use was reduced by 18 and 17% at 1 and 2 tree heights. Three aspects of hydrometeorological significance quality precipitation, the watershed response converting precipitation into streamflow, and the change in streamflow quality, were studied on a forested experimental watershed in central Pennsylvania. Predictive equations were developed for estimating changes in pH, acidity, and alkalinity expected to occur during future stormflows. The independent hydrologic variables which were most highly correlated with changes in H, alkalinity, and acidity were: rainfall recorded prior to a specific precipitation event, antecedent streamflow rate, peak flow rate quickflow volume, and the storm's precipitation amount. Throughfall chemistry can be considerably different than precipitation chemistry. However, there is little information available on the effect of different hardwood species or the portion of the crown that is contacted by the precipitation.

Publications: 83/10 to 84/09

- CORBETT, E.S.; LYNCH, J.A. 1983. Rapid fluctuations in streamflow pH and associated water quality parameters during a stormflow event. In: International symposium on hydrometeorology. 1982 June 13-17; Denver, CO; Bethesda, MD.
- DEWALLE, D.R.; HEISLER, G.M. 1983. Windbreak effects on air infiltration and space heating in a mobile home. *Energ. Build.* 5:279-288.
- EDWARDS, P.J.; HALVERSON, H.G.; DEWALLE, D.R. 1983. Changes in precipitation chemistry yielded to urban runoff by tree crowns. In: 1983 International symposium on urban hydrology, hydraulics and sediment control. 1983 July 25-28.
- HEISLER, G.M.; DEWALLE, D.R. 1984. Technical update: Tree management for energy savings. *Nat. Urban Community For. Forum* 4(4):5-6.
- HORNBECK, J.W.; CORBETT, E.S. DUFFY, P.D. LYNCH, J.A. 1984. Forest hydrology and watershed management. In: *Forestry handbook*. New York, NY: John Wiley and Sons;

06.084 CRIS0085361
IMPACT OF OZONE AND ACID RAIN ON PRODUCTIVITY OF PENNSYLVANIA FORESTS

DAVIS D D; Plant Pathology; Pennsylvania State University, University Park, **PENNSYLVANIA** 16802.
 Proj. No.: PEN02661 Project Type: HATCH
 Agency ID: CSRS Period: 01 JAN 83 to 31 DEC 85

Objectives: Correlate historical changes in regional scale air pollution stress with changes in growth patterns of selected forest trees.

Approach: Temporal changes in air pollution stress, such as airport haze data, will be correlated with tree growth as measured using dendroecological analysis of tree cores. Tree cores will be obtained from six species of trees at each of the six study sites in Pennsylvania.

Progress: 81/01 to 81/12. A collaborative study with the Oak Ridge National Laboratory and the U.S. Geological Sciences Tree Ring Lab has been undertaken to correlate temporal changes in air pollution stress with tree growth, as measured using dendrochronological analysis of tree cores. Three graphically separated areas have been established in Pennsylvania within Centre County, Huntingdon County and Westmoreland County. More than 1,000 increment cores have been taken mainly from the following coniferous and broadleaved tree species: eastern white pine, pitch pine and eastern hemlock; scarlet oak, red oak, chestnut oak, white oak, white ash, black cherry, tulip poplar, pignut hickory and basswood. At each location, cores were taken from sites deemed to be "poor" or "good" in terms of tree growing ability; that is, having low or high site quality. Raw ring widths have been measured and tree ring analyses currently are being conducted to determine if growth patterns (including both linear growth and cross-sectional area growth) can be correlated with climate (i.e. rainfall, temperature, Palmer drought indices), ozone levels (i.e. airport haze surrogate data), or industrial production (i.e. coal consumption).

Publications: 81/01 to 81/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

06.085 CRIS0097102
EFFECT OF ATMOSPHERIC DEPOSITION ON GROWTH AND COMPOSITION OF PENNSYLVANIA FORESTS

DAVIS D D; Plant Pathology; Pennsylvania State University, University Park, **PENNSYLVANIA** 16802.
 Proj. No.: PEN02851 Project Type: HATCH
 Agency ID: CSRS Period: 01 JAN 86 to 31 DEC 88

Objectives: Determine the effects of atmospheric deposition (SO₂) on forest composition and identify criteria which can be used to measure sensitivity of forest ecosystems to air pollution.

Approach: Field studies will be conducted in an oak-hickory forest along a gradient of SO₂ emitted from a rural, coal-fired power plant. Various measures of forest community composition, such as the Shannon Diversity Index, will be used to characterize the forests along the gradient. Increment cores will be taken and dendrochronological analyses conducted.

06.086 CRIS0047812
DETRIMENTAL EFFECT OF DUSTS EMITTED BY VARIOUS INDUSTRIES ON TREES AND FOREST BIOTOPE

GRESZTA J; DOCHINGER L S; Botany; Polish Academy of Sciences, Krakow, **POLAND**
 Proj. No.: WO-PL-FS-81 Project Type: GRANT
 Agency ID: FS Period: 04 AUG 77 to 01 JAN 84

Objectives: Evaluate the effect of various dusts emitted by industry on trees and associated vegetation.

Approach: Plots containing pine and mixed pine-oak will be treated with dust emitted by nonferrous mills, power stations, and building materials industry to determine the resistance of individual ecosystems to industrial pollutants. effects on biological activity of forest soil an associated contamination of soil and ground water will be determined. The fate of microelements introduced into soil will be measured.

Progress: 83/10 to 84/09. Cadmium, aluminum, and zinc dusts caused approximately 95% mortality of the understory in plots receiving 100 T/km. *Quercus robur*, *Sorbus aucuparia*, *Podus avrium*, and *Pinus sylvestris* were extremely sensitive to these metallic dusts. Higher doses, 2000 to 5000 T/km, from power and cement plants caused reductions in increment growth. In all plots dusts affected the understory the most, then the shrubbery, and trees, the least. pH changes were recorded only in the top layers with dusts from the agglomerating, electric power, zinc, and cadmium plants. During the second and third year, higher nitrogen readings were measured on plots covered with dusts from aluminum, zinc, electric power, and cement plants. No movements of trace elements beyond 20 cm of the humus-mineral stratum were recorded. Highest amounts of calcium and sodium were obtained in lysimeters on plots treated with aluminum, zinc; chlorides with cadmium; nitrates with aluminum; and carbonates with agglomerating and cement dusts. Particles from electric power and agglomerating plants stimulated most microbiological processes, however, filiform fungi were inhibited. Cadmium dusts decreased the number of bacteria but increased the growth of filiform fungi. Insect population changes may result from industrial contamination on biocenosis. Dust from agglomerating and power plants did not cause any changes in the above ground entomofauna whereas aluminum and cadmium dusts did.

Publications: 83/10 to 84/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

06.087 CRIS0045917
A GENETIC BASIS FOR FOREST TREE RESISTANCE TO TOXIC GASES

MEJNARTOWICZ L; KRUGMAN S; Inst of Dendrology; Polish Academy of Sciences, Kornik, **POLAND**
 Proj. No.: WO-PL-FS-86 Project Type: GRANT
 Agency ID: FS Period: 01 OCT 79 to 31 DEC 84

Objectives: Determine the genes and genotypes occurring in maternal populations. Determine and identify genotypes of resistant and susceptible trees.

Approach: Determine the response of selected trees to the action of SO₂ under controlled conditions. Use isozyme techniques to describe the genotypes. Investigate the differences in anatomical structure between resistant and susceptible trees. Use fertilizers to influence resistance.

Progress: 79/10 to 84/12. Isozyme techniques were used to detect population changes caused by atmospheric deposition, i.e., fluorides, sulphur dioxide and heavy metals. Among the results found was that for tolerant Scots pine acid phosphatase (APH) was 20-fold lower than trees of the same tolerance growing in "non" polluted areas. Significant differences in malate dehydrogenase was found between resistant and sensitive trees. Difference in phenolic compounds were also detected. The isozyme method can be used to follow stand dynamics under stress from atmospheric deposition.

Publications: 79/10 to 84/12
 MEJNARTOWICZ, L. 1984. Enzymatic investigations on tolerance of forest trees Chapter 25. In. Gaseous air pollutants and plant metabolism. Ed. M.J. Kozol and F.R. Whatley, Butterworths, London: 381-398.

06.088 CRIS0092273
EFFECT OF CARBON DIOXIDE ENRICHMENT ON CONTAINERIZED LOBLOLLY PINE SEEDLING

MILLER A E; Forestry; Clemson University, Clemson, **SOUTH CAROLINA** 29631.
 Proj. No.: SCZ00120-FR

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 FEB 84 to 31 JAN 87

Objectives: Accelerate growth and development of containerized loblolly pine planting stock. Compare rates of carbon dioxide uptake by successive foliage types during loblolly pine seedling ontogeny. Measure survival potential of outplanted containerized loblolly pine planting stock grown in enriched carbon dioxide atmospheres.

Approach: Preplanted containerized seedlings will be exposed to ambient air, air with 500 ppm CO₂, and air with 1000 ppm CO₂. Seedlings will be grown for nine weeks and sampled at 2, 4, 6, and 8 weeks to assess progress of development. Dry weight, height, diameter, and amount of foliage will be measured and anatomical observations will be made. After nine weeks seedlings will be hardened off outside for two weeks in November and then planted in the field using an appropriate field plot design. Height and diameter will be measured monthly following planting. The second and third trial will be similar; however, refinements of CO₂ applications will be made.

Progress: 84/01 to 84/12. Construction of equipment needed for the study has been completed. Four air-tight growth chambers were made using upright freezer bodies set in a horizontal position. Air conditioners are inserted in one end for air circulation and temperature control. Clear plexiglass tops are positioned in place of the freezer doors and 400 watt metal halide lamps are being used for lighting. Carbon dioxide (175, 350, 750, and 1,500 ppm) is measured using an infrared gas analyzer linked with an Apple IIe computer. An I/O card was constructed for the computer to control solenoid valves for sampling and injecting carbon dioxide in the chambers. An A/D converter was purchased to read output from the analyzer. The first trial using containerized loblolly pine is currently in progress.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

06.089* CRIS0091494
THE IMPACT OF ACID PRECIPITATION ON PIEDMONT FOREST SOILS

VAN LEAR D H; Forestry; Clemson University, Clemson, **SOUTH CAROLINA** 29631.
Proj. No.: SC201806-FR Project Type: STATE
Agency ID: OCI Period: 01 AUG 82 to 30 JUN 85

Objectives: To determine the importance of anthropogenic inputs of acidity, natural internal production of acidity, and tree harvesting techniques to nutrient losses from a Piedmont forest soil. To evaluate present and potential future adequacy of soil nutrients for sustained forest productivity based on measurement of present nutrient pools in forests, nutrient status of soils, nutrient losses by acid deposition, natural internal processes, and tree harvesting.

Approach: Precipitation and throughfall will be collected by 10 open-bucket collectors in and adjacent to a 42-year-old loblolly pine plantation and two recently clearcut watersheds. Contents of all containers will be composited after each collection for chemical analysis. Lysimeters at two depths at 5 locations will sample the soil solution on a monthly basis. Nutrient loss from each watershed is determined by samples collected weekly below in H-flume equipped with a .61 m Coshocron wheel. Nutrient content of both overstory and understory vegetation as well as the forest floor and mineral soil to a 60 cm. depth has been completed. The effect of acid precipitation on cation losses will be determined by measuring cations in solution.

Progress: 84/01 to 84/12. Objectives of this project are to evaluate effects of acidic deposition, natural leaching, and timber harvest on cation losses from forest sites. Nutrient dynamics have been monitored on a mature loblolly pine stand, a conventionally harvested stand, and a whole-tree harvested stand. During 1984, precipitation, throughfall, stormflow, and soil solution samples were collected, analyzed, and added to the data base

previously established. Hydrologic export of cations via stormflow and leaching was greater than that removed in either harvest method. Preliminary results indicate that the majority of the basic cations leached from these sites is due to anthropogenic sources of anions. Sulfate anions account for 40-70 percent of total cation leaching.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

06.090* CRIS0084378
CHANGES IN WATER QUALITY ASSOCIATED WITH LOWLAND FOREST SITE CONVERSION

WILLIAMS T M; ASKEW G R; Forestry; Clemson University, Clemson, **SOUTH CAROLINA** 29631.
Proj. No.: SC200526-FR Project Type: STATE
Agency ID: OCI Period: 30 SEP 80 to 01 OCT 83

Objectives: Evaluate changes in water quality on wet sites which have received combinations of logging, logging and site preparation, and pine plantation establishment.

Approach: Kilsock Bay, a Carolina bay owned by International Paper Company, has already been divided into subwatersheds by draining and ditching. Stand conditions which will be monitored are natural hardwoods, active logging, completed logging, site prepared areas, young pine plantations and older pine plantations. One storm flow sequence will be collected at 20 points once per month. The following variables will be measured; Temperature, dissolved O(2), pH, flow, dissolved PO(4), NO₃ N, suspended sediment, total P and N in water and sediment and Ca, K, and Mg using standard analytical methods.

Progress: 84/01 to 84/12. A second phase study was begun to ascertain the source of elevated sulfate concentrations in several subwatersheds. Sulfate input and acid precipitation appears to be associated with stagnant high pressure rather than easterly winds. This, along with sulfate to chloride ratio, indicates sea salt aerosols are not the source of sulfate. Aerosol impaction on tree crowns increases sulfate concentration in throughfall by 50% and in stemflow by 100%.

Publications: 84/01 to 84/12
ASKEW, G.R. and WILLIAMS, T.M. 1984. Sediment concentrations of intensively prepared wetland sites. So. J. App. For. 8(3):152-157.
WILLIAMS, T.M. and ASKEW, G.R. 1985. Water Quality Changes Associated with Forest Drainage and Pine Plantation. Establishment in Proceedings. Third Southern Silvicultural Symposium. (In press).

06.091 CRIS0088663
EFFECTS OF AIR POLLUTION ON RADIAL GROWTH AND WOOD DENSITY OF TREES

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 University of Tennessee, Knoxville, TENNESSEE
 37916.

Proj. No.: TEN-MS-36

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 08 OCT 82 to 30 SEP 86

Objectives: Determine whether pollution produced by coal-fired steam plants, mainly SO(2), has an effect on the radial growth and wood density of deciduous hardwood trees.

Approach: Trees that are upwind and downwind from two coal-fired steam plants in East Tennessee will be sampled to compare their radial growth and wood density in periods prior to and following the initiation of operation. Locations as far as 60 miles downwind from the plants will be examined. Pollution stress on tree ring development will be determined after the effects of trend and climatic stress have been removed.

Progress: 84/01 to 84/12. Five sites in eastern Tennessee were selected to study the effects of acid fallout on two genera, *Carya* and *Quercus*. Five hundred cores were extracted, mounted and scanned with a gamma densitometer to determine average, maximum, average maximum, minimum, and average minimum density of wood accumulated during the periods 1940-45 and 1970-75. These periods, which represent pre and post-pollution onset, are being compared to determine whether differences in wood properties exist. A computer program has been written which will determine the above-named properties using raw data produced by the densitometer.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

06.092 CRIS0049037
THE ROLE OF ENVIRONMENTAL STRESS ON TREE GROWTH AND DEVELOPMENT

GREGORY R A; TABOR C A; WONG B L; Northeastern Forest Experiment Station; USDA Forest Service, Burlington, VERMONT 05402.

Proj. No.: NE-1112 Project Type: INHOUSE
 Agency ID: FS Period: 19 AUG 83 to 19 AUG 88

Objectives: To evaluate the effect of environmental stress on the anatomical development and physiological functions of trees of the conifer and northern hardwood ecosystems.

Approach: Determine the physiological effects of site acidification on tree growth and development through studies of incorporation of Al and other metals in cell-walls, concentration of metals in xylem sap during spring mobilization, study of the effect of mobile elements on membrane permeability enzyme activity, and ion uptake. Determine the anatomical and physiological effects of stress and its possible role in predisposing trees to

decline through studies of natural and artificial defoliation and resultant meristem survival, shoot development and sap-sugar concentration.

Progress: 83/10 to 84/09. In a survey of 20 red spruce stands in Vermont, we quantified visual symptoms of stress and correlated these with levels of several physiographic and vegetative characteristics. Stress increased significantly with elevation. It was also positively correlated with abundance of seedling mycorrhizae and with O(2)-horizon concentrations of lead and copper. Stress was not significantly associated with soil pH, texture or depth, stand aspect, age, slope position basal area or relative abundance of spruce. Studies of the concentrations of major elements and trace metals in xylem sap and tissues of several Northeastern tree species have led us to hypothesize that the much higher-than-normal input of atmospheric nitrogen at higher elevations may be a factor in the decline of red spruce. We are presently looking at nitrogen concentrations in the xylem sapstream, foliage, and other tissues relative to spruce decline. We have succeeded in growing a native mycorrhizal species, a symbiotic root fungus that is essential for efficient mineral uptake by tree roots, in a highly controlled laboratory medium. Experiments so far show that pH of this medium does effect growth of the fungus, but if pH is allowed to drop gradually, from 5.5 to 3.0, there is little change in its growth rate suggesting that low soil pH alone is not detrimental to its existence. We plan next to test the effects of trace metals at the concentrations observed in high elevation soils on growth and survival of native mycorrhizal species.

Publications: 83/10 to 84/09
 FRIEDLAND, A.J.; GREGORY, R.A.; KAREN LAMIP, L. & JOHNSON, A.H. 1984. Winter damage to foliage as a factor in red spruce decline. Can. J. For. Res. (In Press).

06.093 CRIS0097363
ECONOMIC ANALYSES TO ASSESS ATMOSPHERIC POLLUTION IMPACTS IN EASTERN FOREST

LEUSCHNER W A; Forestry; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.

Proj. No.: VA-632637

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 JAN 86 to 31 DEC 88

Objectives: This is an exploratory study to suggest methods and procedures to modify existing economic models, or to develop new ones, in order to estimate the on-site economic impact of air pollution.

Approach: Develop an a priori model of potential physical and biological impacts based on existing knowledge of atmospheric pollution damages and forest biology. This part of the study will systematically identify the major types and frequency of pollutants and their specific impact on individual trees and on the forest collectively. The pollutants and their impacts, in turn, can be used to identify

forest products which are likely to be impacted. Review the forest protection economics literature and identify economic models and procedures likely to be useful in measuring the economic impact of air pollution on the forest products identified in the first step above. Modify these published models into several models which will be useful in estimating atmospheric pollution impact. It is also probable that new models will be suggested.

06.094 CRIS0069843
EFFECT OF AIR POLLUTANTS ON GROWTH AND YIELD OF FOREST TREES, ORNAMENTALS AND FIELD CROPS

MOORE L D; SKELLY J M; Plant Pathology & Physiology; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
 Proj. No.: VA-0202390 Project Type: STATE
 Agency ID: SAES Period: 01 JAN 76 to 30 SEP 82

Objectives: Evaluate the impact of air pollution found in Virginia on forest trees, woody ornamentals, and certain field crops. Determine how air pollution affects certain chemical constituents of plants. Develop practical measures of alleviating plant injury by cultural or genetic methods.

Approach: Selected species, cultivars and/or hybrids will be studied under field and controlled conditions. The effect of ambient and controlled levels of pollutants on growth and development will be determined. Radial increment growth studies and the development of a bioindicator system will be used to study pollution abatement programs. Selected plants will be assayed for certain chemical constituents. The influence on N, P, K, and Ca levels on the sensitivity of plants to pollutions will be ascertained.

Progress: 82/01 to 82/12. Five air pollution monitoring sites were maintained on the Blue Ridge and Appalachian Mountains of Virginia. Pollution intensity was determined over a 5-year period and correlated with damage to white pines. Significant reduction in foliar biomass of plants grown in non-filtered chambers at the sites showed that low levels of pollutions were detrimental. Ozone and sulfur dioxide tolerant plant material of azalea, rhododendron, white pine, loblolly pine and tobacco cultivars, lines and/or hybrids was identified. Studies of the importance of mineral nutrition in altering the sensitivity of tobacco and whitepine to ambient oxidant levels showed that N, P and Ca could be used to reduce pollution sensitivity. The use of specific herbicides to reduce the sensitivity of tobacco transplants to oxidants has been very successful. Investigations of the effects of pollution on numerous chemical constituents as well as plant biomass showed the importance of subclinical levels of pollution on tobacco production in Virginia. Results of this project are now being incorporated into agricultural practices in Virginia.

Publications: 82/01 to 82/12

- BENOIT, L. F.. and SKELLY, J. M.. and MOORE, L. D.. and DOCHINGER, L. S., 1982, Radical growth reductions of *Pinus strobus* L. correlated with foliar ozone sensitivity., *Can. J. Forest Res.* 12:673-678.
 REILLY, J. J.. and MOORE, L. D., 1982, Influence of selected herbicides on ozone injury in tobacco (*Nicotiana tabacum*)., *Weed Sci.* 30:260-263.
 DUCHELLE, S. F.. and SKELLY, J. M.. and CHEVONE, B. I., 1981, Oxidant effects on forest tree seedling growth in the Appalachian Mountains., *Soil, Water, Air Pollut.* 18:363-365.
 PHILLIPS, S. O.. and SKELLY, J. M.. and BURKHART, H. E., 1977, Inhibition of growth in asymptomatic white pine exposed to fluctuating levels of air pollution., *Phytopathology* 67:721-725.
 TREVATHAN, L. E.. and MOORE, L. D., 1981, A study of calcium fertilization on weather fleck and chemical composition of flue-cured tobacco., *Tobacco Sci.* 25:102-105.

06.095 CRIS0074237
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

SKELLY J M; Plant Pathology & Physiology; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
 Proj. No.: VA-0622291 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establishing an Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States; investigating the transport and transformations of atmospheric constituents; and organizing and coordinating research in the SAES, FS, and other research institutions and agencies on the effects of changes in atmospheric deposition on: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters; the health and productivity of domestic food animals, wildlife, and fish; and the corrosion of metals, painted surfaces, masonry, and other materials in machinery or structures.

Approach: A collection device for wet and dry deposition will be located adjacent to a meteorological station at the Horton Research Center at Salt Pond Mountain, Virginia. The interaction of ozone and related atmospheric deposition on eastern white pine will be investigated by means of field and laboratory tests.

Progress: 83/01 to 83/12. Sampling of wet and dry deposition was done for at least four years during this project at several sites in southwestern Virginia. The most intensive sampling was done at a site developed on Salt Pond Mountain. Auxiliary monitoring was done at sites in Shenandoah National Park, southern sections of the Blue Ridge Parkway, and the

campus at Blacksburg, Virginia. Monitoring data showed mean pH values of rainfall were about 4.4 and the lowest value was 3.2. Chemical analysis showed rainfall acidity was correlated with sulfate concentrations. Analysis of pollutants in air and rainfall helped define the scope of pollution problems in Virginia, suggested realistic pollution problems in Virginia, led to realistic pollution exposure regimes in laboratory experiments, and contributed to national network established to define patterns of wet and dry air pollution deposition. A number of experiments, in the field and laboratory, have been aimed at determining the responses of plants to gaseous air pollutants and acid rain. Field experiments have focused on the analysis of trees raised in open top chambers in order to manipulate pollution concentrations. CSTR chambers were used to expose greenhouse-raised plants to controlled air pollution doses. In general, the analysis of foliar injury and plant growth indicated ambient levels of gaseous air pollutants were more injurious to vegetation than ambient levels of acidity in precipitation.

Publications: 83/01 to 83/12

- CHEVONE, B.I. and SKELLY, J.M. and GARDNER, D.W., 1981, Acid rain: destructive flood or gentle warning?, Va. Forests. 37(1):10-13.
- SKELLY, J.M. and CHEVONE, B.I., 1981, Interactive effects of ozone, sulfur dioxide, and nitrogen oxides on vegetation: potential confounding by acidic precipitation, Proc. Amer. Chem. Soc., 181st Ann. Mtg, Atlanta, GA.
- CHEVONE, B.I., 1981, Concepts of acidic rain: Terrestrial vegetation effects, Proc. Seventh Ann. Soc. Res. Mtg. National, Park Service, S.E. Region, Gatlinburg, TN.
- LACY, G.H. and CHEVONE, B.I. and CANNON, N.P., 1981, Effects of simulated acid precipitation on *Erwinia herbicola* and *Pseudomonas syringae* populations, Phytopathology 71:888.

06.096 CRIS0094848
THE COMBINED EFFECTS OF GASEOUS POLLUTANTS AND ACID RAIN ON SEEDLING TREE GROWTH.

CHEVONE B I; Plant Pathology Physiology & Weed Science; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
Proj. No.: VA-612599 Project Type: HATCH
Agency ID: CSRS Period: 01 JAN 85 to 31 DEC 87

Objectives: To characterize the effects of ozone, sulfur dioxide and acid rain on seedling tree development using growth analysis techniques. To determine the effects of soil chemical composition on seedling response to air pollutants. To investigate the effects of air pollutants on seedling physiology.

Approach: Fumigate forest tree seedlings with ozone and/or sulfur dioxide in combination with applications of acidic rain of different pH values. Assess symptom development and measure growth analysis components including relative growth rate, leaf area ratio, leaf weight ratio, root shoot ratio, mean unit leaf rate and net assimilation rate. Measure chlorophyll

content and gas exchange rates. Measure root length and the effect of soil aluminum concentrations on root growth.

Progress: 84/01 to 85/09. Recent research results have included several studies investigating the growth response of seedling trees to combined pollutant stresses. Ozone (O₃) and sulfur dioxide (SO₂) inhibited loblolly pine growth more extensively than either pollutant alone. This effect was more evident on root growth than shoot growth. Colonization of seedlings by the mycorrhizal fungus *Pisolithus tinctorius* altered plant response to pollutant exposures and promoted root growth such that no pollutant effects occurred. In yellow-poplar seedlings exposed to O₃, SO₂ and/or simulated acid rain, the mixture of O₃ and SO₂ inhibited height growth and dry matter accumulation, but stimulated leaf area ratio, compared to control plants. The effect of O₃ and SO₂ was additive for most plant growth components. Simulated rain treatments (pH 3.0, 4.3 and 5.6) altered leaf dry mass as a quadratic function of pH. Dry mass was greatest at pH 4.3 irrespective of O₃ or SO₂ treatment. A significant rain pH x gaseous pollutant interaction occurred for numerous plant growth components. In general, as the pH of simulated rain decreased, the O₃ effect became more intense, whereas the SO₂ effect became less severe. These studies demonstrate that pollutant mixtures are more deleterious to plants than individual pollutants.

Publications: 84/01 to 85/09

- MAHONEY, M.J. and CHEVONE, B.I. and SKELLY, J.M. and MOORE, L.D., 1985, Influence of mycorrhizae on the growth of loblolly pine seedlings exposed to ozone and sulfur dioxide, Phytopathology 75:679-682.
- CHEVONE, B.I. and YANG, Y.S. and WINNER, W.E. and STORKS-COTTER, I. and LONG, S.J., 1984, A rainfall simulator for laboratory use in acidic precipitation studies, J. Air Pollut., Contr. Assoc. 34:355-359.
- CHAPPELKA, A.H. and CHEVONE, B.I. and BURK, T.E., 1985, Growth response of yellow-poplar (*Liriodendron tulipifera* L.) seedlings to ozone, sulfur dioxide, and simulated acidic ... in combination, Environ. Expt. Botany 25: 233-244.
- CHAPPELKA, A.H. and CHEVONE, B.I. and BURK, T.E., 1984, Growth response of yellow poplar seedlings to simulated acidic precipitation, ozone and sulfur dioxide, Phytopathology 74:755 (Abstr).
- CHAPPELKA, A.H. and CHEVONE, B.I. and BURK, T.E., 1984, Ozone (O₃), sulfur dioxide (SO₂) and acidic rain effects on growth of white and green ash seedlings, Phytopathology 74:870 (Abstr).

06.097 CRIS0093371
GROWTH RESPONSE AND DROUGHT SUSCEPTIBILITY OF FOREST TREES EXPOSED TO ACID RAIN AND OZONE

CHEVONE B I; JOHNSON J D; SEILER J R; Plant Pathology Physiology & Weed Science; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
Proj. No.: VA-336228-1

Project Type: SPECIAL GRANT
Agency ID: CSRS Period: 01 JUN 84 to 31 MAY 87

Objectives: Investigate the combined effects of ozone and acid rain on root and shoot growth, drought susceptibility, and plant water status in seedlings of four forest tree species.

Approach: Seedling trees will be exposed to ozone and simulated acid rain for a ten-week period. Relative growth of shoots and roots during this period will be determined by small sample harvesting at 2 1/2 week intervals. Seedlings will be subjected to drought stress after the exposure and drought susceptibility will be determined by measuring, foliar gas exchange rates, leaf or needle water potential, and root hydraulic conductance during drought stress.

Progress: 84/01 to 85/09. Research results on this project at present include a preliminary study of red spruce seedling growth response to acidic precipitation and ozone (O₃). Six-month-old 'wild type' red spruce plants were exposed to O₃ and simulated acid rain (pH 3.0, 4.3 and 5.6) for 6 weeks. Across all rain treatments, shoot dry mass was significantly less for seedlings fumigated with O₃ compared to unexposed control plants. A significant O₃ X rain interaction occurred for cumulative height growth. When seedlings were exposed to rain treatments only, height increase was 32% greater at pH 3.0 compared to pH 5.6. The addition of 0.1 ppm O₃ (4h/d, 5d/wk) resulted in 32% less growth at pH 3.0 compared to pH 5.6. Preliminary analyses of experiments with loblolly pine seedlings indicated that O₃ exposure results in less root biomass, an effect enhanced by the additional stress of pH 3.0 simulated rain. After 8 wks exposure to O₃ and acid solutions, root hydraulic conductance (RHC) did not appear to be significantly altered. Preliminary analysis of experiments with yellow-poplar seedlings indicated that O₃ and simulated acid rain exposure did not alter RHC after a single, short-term drought period in which leaf water potential exceeded -15 bars for only 10 to 12 hours.

Publications: 84/01 to 85/09

CHAPPELKA, A.H. and CHEVONE, B.I. and SEILER, J.R., 1985, Growth response of red spruce seedlings to acidic precipitation and ozone: preliminary results, Proc. SWFDW Wrightsville Beach, NC, June 11-13 (Abst).

06.098 CRIS0074470 REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

CHEVONE B I; MOORE L D; WINNER W E; Plant Pathology Physiology & Weed Science; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
Proj. No.: VA-622292 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield, and quality. To determine mechanisms of tolerance of plant cultivars to

air pollutants and interactions with biotic and abiotic factors. To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: Fumigate field crops and forest tree species with ozone, sulfur dioxide and nitrogen dioxide singly and in various combinations with acidic rain. Measure symptoms, growth parameters, chlorophyll, carbohydrates and sulfur levels. Inoculate pollution stressed plants with *Phytophthora* or *Collectotrichum* and determine the rates of disease development and the disease severity. Measure changes in carbohydrate and lipid levels in leaves and roots and absolute changes in enzymes and compounds involved in photosynthesis. Screen bean, pine, ash and tobacco cultivars, lines and introductions for tolerance to acidic rain, ozone and sulfur dioxide. Screening includes field trials and fumigation tests.

Progress: 84/01 to 85/09. Soybeans were exposed to 0.20 ppm ozone and 0.70 ppm sulfur dioxide in various combinations. Fumigations were administered for 2 h either as a single pollutant (O₃ or SO₂), simultaneously (O₃ + SO₂) or in overlapping pollutant combinations. After 2 h exposure to O₃ or SO₂ the carbon dioxide exchange rate (CER) was affected. Exposure to O₃ followed by O₃ + SO₂, SO₂ followed by SO₂ + O₂ and continuous O₃ + SO₂ significantly reduced CER. However, stomatal resistance was only altered by the simultaneous fumigation with O₃ + SO₂. These results suggest that SO₂ and O₃ affect different biochemical processes associated with CO₂ metabolisms. Plant species had patterns of visible foliar injury that reflected SO₂ - stress gradients near Hawaiian volcano vents. Injury reflected, in part, species differences in stomatal response to SO₂. The most seriously injured leaves do not close their stomata when exposed. The most SO₂ - resistant species were the most abundant indicating volcanic SO₂ may exert selective forces on community development. A general model of annual SO₂ absorption was calculated for both mosses and vascular plants to determine if differences in absorption could account for extreme SO₂ sensitivity known for mosses. Analysis of SO₂ absorption took into account seasons, precipitation, evergreen forests, deciduous forests, arctic tundras, and deserts. SO₂ absorption for mosses ranged from 30 to 400 fold higher for mosses than for vascular plants.

Publications: 84/01 to 85/09

CHEVONE, B. I. and YANG, Y. S., 1985, CO₂ exchange rates and stomatal diffusive resistance in soybeans exposed to O₂ and SO₂, Can. J. Plant Sci. 65:267-274.

WINNER, W. E. and MOONEY, H. A., 1985, Ecology of SO₂ resistance V. Effects of Volcanic SO₂ on Native Hawaiian Plants, Oecologia, 66:387-393.

WINNER, W. E. and ATKINSON, C. J., 1985, Annual Absorption of Gaseous Air Pollutants by Mosses and Vascular Plants in Diverse Habitats, In: the Effects of Acid Deposition on Forests, Wetlands, and Agricultural Ecosystems. In Press.

06.099 CRISO084447
**INTERACTIONS OF SITE FACTORS & AIR POLLUTANTS
 IN INFLUENCING GROWTH AND SURVIVAL OF FOREST
 TREES**

KOZLOWSKI T T; Forestry; University of
 Wisconsin, Madison, WISCONSIN 53706.
 Proj. No.: WIS02599

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: To qualify effects of adverse site factors (water supply, mineral supply, shading) and air pollutants, alone and in combination, on physiological responses and growth of forest trees. To determine the extent to which adverse site factors modify the impact of air pollutants on forest trees (and the reverse).

Approach: Quantitative experiments will be conducted with species tolerant or intolerant to air pollution and to adverse site factors. Seedlings will be exposed to adverse site factors and to SO(2) at various dosages. The order of treatment will also be reversed. Measurements will be made of pollutant uptake, chlorophyll content, stomatal aperture, photosynthesis, translocation of carbohydrates, reserve carbohydrates, ethylene production, and growth of leaves, stems, and roots. Data will be analyzed to determine how site stresses affect tree responses to pollution, how pollution affects tree responses to site stresses.

Progress: 84/01 to 84/12. 1. *Tilia americana* seedlings were exposed to 1 mu / SO(2) for 24, 48, or 96 hrs. Unfumigated and fumigated seedlings were grown in the light or shade (1/3 or full light) of 60 days. No leaf injury was present at the end of any fumigation treatment. However, within 35 days after fumigation ended chlorotic and necrotic lesions began to appear on previously fumigated plants, with injury occurring earlier, and extent of injury greater as duration of exposure to SO(2) was increased. Leaf abscission was extensive only on seedlings fumigated for 96 hrs. More leaf injury developed on fumigated seedlings kept in the light than on those maintained in shade. 2. Stomata of 14-wk-old *Fraxinus americana* seedlings exposed to 1 or 2 mu / SO(2) for 48 hrs subsequently opened more slowly at high relative humidity (75%), and closed more slowly at low humidity (25%) than did stomata of unfumigated plants. Also stomata of previously fumigated plants were more open at low temperature (15 C) and more closed at high temperature (25 C) than were stomata of unfumigated plants. 3. Stomata of 16-wk-old *Acer platanoides* seedlings that had previously been exposed to 1 mu / SO(2) for 48 hrs did not respond differently to humidity changes than did stomata of unpolluted seedlings. Stomata of unfumigated and fumigated plants opened at the same rate in high humidity and closed in low humidity. No injury was evident in polluted seedlings.

Publications: 84/01 to 84/12

SHANKLIN, J.J. and KOZLOWSKI, T.T. 1984.
 Effect of temperature preconditioning on
 response of *Fraxinus pennsylvanica*

seedlings to SO(2). Environ. Pollut. 36:
 311-326.

SHANKLIN, J. and KOZLOWSKI, T.T. 1984. Effect of flooding of soil on growth and subsequent responses of *Taxodium distichum* seedlings to SO(2). Environ. Pollut. (accepted).

TSUKAHARA, H., KOZLOWSKI, T.T. and SHANKLIN, J. 1984. Tolerance of *Pinus densiflora*, *P. thunbergii*, and *Larix leptolepis* seedlings to SO(2). Plant and Soil. (accepted).

KOZLOWSKI, T.T., Ed. 1984. Flooding and Plant Growth. Academic Press, New York, 356 pp.

KOZLOWSKI, T.T. 1984. Introduction. In Flooding and Plant Growth (T.T. Kozlowski, ed), pp. 1-7. Academic Press, New York.

06.100* CRISO087161
**REGIONAL INTEGRATED LAKE-WATERSHED
 ACIDIFICATION STUDY (RILWAS)**

BOCKHEIM J G; Soil Science; University of
 Wisconsin, Madison, WISCONSIN 53706.
 Proj. No.: WIS02710 Project Type: STATE
 Agency ID: SAES Period: 01 JUL 85 to 30 JUN 88

Objectives: To monitor the quantity and quality of wet and dry deposition, throughfall, and soil water leachate in various forest types at Round and Eastmile Lakes, northwest Wisconsin, as part of an interdisciplinary study dealing with the effects of acidic deposition on lake chemistry. To study specific mechanisms whereby the terrestrial ecosystem buffers acidic deposition, including foliar leaching, ion exchange, and mineral weathering. To apply the ILWAS Model to predict the effects of acidic deposition on lake chemistry.

Approach: Wet and dry deposition will be collected weekly at each watershed using Aerochem Metric 301 collectors. Nine throughfall collectors have been installed on 4 plots containing representative vegetation at each watershed. Twelve soil water collectors have been located at each of 2 depths (75 and 600 mm) on each plot. All solutions are being analyzed for pH, EC, Al, Si, Ca, Mg, K, Na, NH(4), SO(4), NO(3), Cl, and HCO(3). Temporal changes in tissue concentrations are being measured to determine the relative contributions of foliar leaching and atmospheric deposition to throughfall.

Progress: 84/01 to 84/12. This project is part of an international research program entitled "Regional Integrated Lake-Watershed Acidification Study," funded by the Electric Power Research Institute. The primary objective of the study is to examine the effects of acidic deposition on biogeochemistry of two watersheds featuring contrasting lakes in northwestern Wisconsin. The findings to date are as follows. Whereas the canopies of deciduous forest types such as birch, aspen, and oak reduce the fluxes of H ion, SO(4), and NO(3) in bulk precipitation, throughfall from the canopies of coniferous types such as jack and red pines are enriched in these constituents. Although deciduous forest types are able to neutralize acidic deposition, the ultimate source of buffering is in the soil, as

determined by a similarity in ion fluxes at the base of the effective rooting zone (60 cm) on plots with and without forest cover. The primary mechanism whereby the soils in northwestern Wisconsin buffer acidic deposition appears to be silicate hydrolysis rather than ion exchange. This is supported by simulated weathering studies conducted on soil columns in the laboratory. Whereas leaching with distilled water (pH 5.6) yielded low amounts of Si and negligible change in pH of the extract, leaching with dilute sulfuric acid (pH 3.0) resulted in large concentrations of Si (2 mg/L) and nearly equivalent reduction in pH of the extract as compared to the leaching solution.

Publications: 84/01 to 84/12

- BOCKHEIM, J.G. 1984. Acidic deposition effects on forest soils and site quality, pp. 19-35. In: Forest responses to acidic deposition. Proc. of the conf., held on Aug. 3-4, 1983, Univ. of Maine, Orono.
- ESSER, J.M. 1984. Biogeochemistry of *Quercus* and *Pinus* ecosystems in northwestern Wisconsin. M.S. thesis, Dept. of Soil Science/Forestry, Univ. of Wisconsin-Madison. 103 pp.
- JEPSEN, E.A. and BOCKHEIM, J.G. 1984. Acidic deposition influences on biogeochemistry of four forest ecosystems in northwestern Wisconsin. In: Proc. Sixth Internat. Conf. Environmental Biogeochemistry, Oct. 10-14, 1983.
- BOCKHEIM, J.G., LEIDE, J.E. and ESSER, J.M. 1984. Acidic deposition and ion movements in forest soils of northwestern Wisconsin. In: Proc. Sixth North Amer. Forest Soils Conf., June 20-23, 1983, Knoxville, TN, in press.

CM 07 RANGE

07.001 CRISO066496
RANGE PLANT NUTRITION, RANGE SOILS, AND RANGE
FERTILIZATION

JONES M B; WILLIAMS W A; Agronomy & Range
Science; University of California, Davis,
CALIFORNIA 95616.
Proj. No.: CA-D*-ARS-3307-H Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 86

Objectives: To measure the effect of
fertilization on forage quality as measured by
chemical and botanical composition and animal
productivity. To apply principles of economics
to fertilizer studies. To adapt and update
methods of assaying the nutrient status of
pastures, which will make possible
fertilization for near maximum production.

Approach: Field plots have been and will be
established with varying fertilizer treatments
designed to maximize production. These will be
sampled for chemical and botanical composition,
and productivity will be measured by grazing
animals or by clipped samples for diagnostic
and economic evaluation. Pot studies may be
used to supplement field work.

Progress: 84/01 to 84/12. SULFUR AND FORAGE
QUALITY: S fertilization depressed the level of
Se in clover 60% and in ryegrass 72%. The
depression of Se in blood of lambs on the two
respective pastures was 74 and 80%, indicating
that S fertilization had an additional
depressing effect on Se in the animals.
Yearling ewes gained more on S fertilized
pastures, but Se had little effect on their
rate of gain even though blood Se was depressed
at or below critical levels. MAXIMIZING ANIMAL
GAINS WITH P AND S FERTILIZATION IN PASTURES OF
NORTHERN CALIFORNIA: When lambs were placed on
pasture February 29, P and S increased lamb
gains per acre. Only S increased lamb gain per
head. SEASONAL NUTRIENT CYCLING IN ANNUAL
GRASSLAND SITES UNDER DIFFERENT MANAGEMENT:
Available soil N, S, P, Ca, Mg and K were
measured monthly for two years on six range
sites. Seasonal fluctuations in inorganic N
were similar for both years over all sites;
levels and variation in N were highest during
winter and early spring and lowest during
summer. Generally similar though less
pronounced patterns were observed in available
S, P, and Ca. ATMOSPHERIC DEPOSITION PROGRAM:
Rainwater pH averaged 5.75 in 27 storms in
1983-84. Deposition of S in 41 inches of rain
was 1.02 lb/A. These values indicate that
Hopland continues to have rainfall that is
affected very little by industrial pollution.

Publications: 84/01 to 84/12

- SPENCER, K., FRENEY, J.R. and JONES, M.B.
1984. A preliminary testing of plant
analysis procedures for the assessment of
the sulfur status of oilseed rape. Aust J.
Agric Res 35:163-175.
CENTER, D.M., JONES, M.B. and VAUGHN, C.E.
1984. Effects of sulfur and nitrogen levels
and clipping on competitive interference
between two annual grass species. Agronomy
Journal 76:65-71.
RAGUSE, C.A., HULL, J.L., JONES, M.B.,
MORRIS, J.G., GEORGE, M.R. and OLSON, K.D.
1984. Range fertilization in the Sierra

- Nevada foothills. California Agriculture
38(5&6):4-6.
JONES, M.B. 1984. Report on short-term staff
assignment. Soil fertility and plant
nutrition of rain fed pastures of the
Alentejo region of Portugal, University of
Evora. Portugal University of Institutes
Development Project.
CENTER, D.M. and JONES, M.B. 1984. An
improved esophageal fistula bag for sheet.
Journal of Range Management 37:476-477.

07.002 CRISO096632
THE RESPONSE OF RANGE PLANTS AND ANIMALS TO
VARIOUS TYPES OF GRAZING AND MANAGEMENT SYSTEMS

MURPHY A H; Agronomy & Range Science;
University of California, Davis, CALIFORNIA
95616.
Proj. No.: CA-D*-ARS-4567 Project Type: STATE
Agency ID: SAES Period: 01 OCT 85 to 30 SEP 87

Objectives: Grazing data to evaluate the impact
of costs and returns for sheep use of
grasslands and brush areas is being collected
to better appraise the feasibility of various
improvement practices. Measurements of both
animals and forage need to be accomplished on a
long-term basis. Where brushland improvement is
practiced the environmental conditions relative
to air pollution, water yield, and erosion need
to be explored for more explicit information.
The value of livestock for the control of woody
species needs to be demonstrated as a method of
biological control.

Approach: Field data from grazing studies will
be analyzed with recommendation developed from
data review. Measurement of annual forage
yields will continue, compiling animal use on
pastures where improvement studies are in
progress.

07.003* CRISO062810
UTILIZATION, CONVERSION, AND MANAGEMENT OF
SOUTHERN CALIFORNIA BRUSHLAND

YOUNGNER V B; NUDGE F J; Botany & Plant
Sciences; University of California, Riverside,
CALIFORNIA 92521.
Proj. No.: CA-R*-BPS-2861-H Project Type: HATCH
Agency ID: CSRS Period: 03 OCT 72 to 31 MAR 84

Objectives: Develop a basis for brushland
utilization and management through studies on
potential uses of brush species, effects of
harvesting methods, substitution of exotic
species, seedling establishment, competition
among native and exotic species, physiology of
resprouting.

Approach: Through field, greenhouse, growth
chamber, and laboratory studies. Field studies
will be in natural brushlands and field
plantings, using portable research equipment.
Laboratory analyses to plant tissue
constituents and soil properties will be
correlated with field observations. Specific

environmental responses will be studied in greenhouse and growth chambers.

Progress: 84/01 to 84/03. Investigations of annual range plant responses to the air pollutants O₃ and SO₂ were conducted in fumigation chambers. In *Bromus rubens* ozone both reduced yield and affected several aspects of quality. Sulfur dioxide effects were less and primarily involved quality factors. Interaction of the two pollutants was not shown. Chronic SO₂ exposure of *Bromus mollis* and *Erodium botrys* also resulted in yield reductions with carbohydrate allocation to the root zone being significantly reduced in *B. mollis*. *Erodium* growth showed some stimulation at the low SO₂ level but not at higher levels. Shoot sulfur content in *Bromus* was higher than in *Erodium* at comparable fumigation levels. Detrimental effects of fumigation were often not immediately apparent but developed as the season progressed. These studies indicated that air pollutants affect growth of brushland plants and may change species composition in affected areas. In some regions of high pollutant levels, value of the vegetation for forage and erosion control may be impaired and type conversion to species shown to be more tolerant may be desirable. Preparation of data for formal publication has continued.

Publications: 84/01 to 84/03
NO PUBLICATIONS REPORTED THIS PERIOD.

07.004* CRIS0083194
ECONOMIC ANALYSIS OF NATURAL RESOURCE AND ENVIRONMENTAL ISSUES IN COLORADO

YOUNG R A; WALSH R G; HUSZAR P C; Economics; Colorado State University, Fort Collins, COLORADO 80523.
Proj. No.: COL00328 Project Type: HATCH
Agency ID: CSRS Period: 08 AUG 80 to 30 SEP 83

Objectives: Objectives---The overall objective of the research is to study the demand, supply and economic value of Colorado Natural resources and environmental commodities, and to evaluate market and non-market allocative mechanisms for achieving maximum social return from the resources.

Approach: Analyze the value of water in withdrawal uses (agriculture, households, industries and non-withdrawal uses (recreation); Investigate the economic forces underlying conservation of rural lands to urban uses and evaluate alternative public policies for influencing land use and the extent of urban sprawl evaluate the demand for the management of outdoor recreation on public lands and waters. Evaluate the impact of growing demand for energy on Colorado's economy and environment. Study the economic impacts of natural hazards. Evaluated the economic benefits of air and water quality improvement. Formulate and test new methodologies for ascertaining the economic impacts (in allocative, distributive, and regional dimensions) of changes in the demand for non-marketed environmental goods and services.

Progress: 83/01 to 83/09. The overall objective of this research program is to study the demand, supply and economic aspects of Colorado's natural resources and environmental endowments, to evaluate market and non-market allocation mechanisms for achieving optimal social returns from natural resources, and to assist in conflict resolution via public policy analysis arising from competing uses of these resources. During this time period, research continued on water use allocations and quality aspects, groundwater use in agriculture, an updating of Colorado water case law, option demand for recreational uses, values of hunting and fishing in Colorado, some preliminary work on the grasslands plowout problem in eastern Colorado, and related natural resource economics issues. Due to reorganization of agricultural programs at CSU, a new Department of Agricultural and Natural Resource Economics was established in the College of Agricultural Sciences on July 1, 1983. As a result of this action, this project (Colo 328) is being terminated and will be replaced by a new reoriented research project, "Natural Resource Economics and Regional Resource Allocation Issues", effective October 1, 1983.

Publications: 83/01 to 83/09
DAVITT, G.J. and WALSH, R.G. 1983. A demand function for length of stay on ski trips to Aspen. Journal of Travel Research. 21(Spring).
MCKEAN, J.R. and WEBER, J.C. 1983. The economy of Lincoln, Sublette, Sweetwater and Uinta Counties, Wyoming, Rock Springs BLM District, Technical Report No. 40, Colorado Water Resources Research Institute, Colorado State University.
MCKEAN, J.R. and NOBE, K.C. 1983. 1981 Colorado sportsman survey: Direct and indirect effects of expenditures for hunting and fishing in Colorado (Contract Report for Colorado Division of Wildlife and Bureau of Land Management).
GILLIAM, L.O., MILLER, N.P. and WALSH, R.G. 1983. Congestion and willingness to pay for expansion of skiing capacity. Land Economics 59. (May 1983).
GILLIAM, R.A., LOOMIS, J.B. and WALSH, R.G. 1984. Valuing option, existence, and bequest demands for wilderness. Land Economics 60. (February 1984).

07.005* CRIS0081176
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

GIBSON J H; Office of The Director; Colorado State University, Fort Collins, COLORADO 80523.
Proj. No.: COL00223 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish Atmospheric Deposition Network to determine spatial and temporal trends in supply of beneficial nutrient elements and potentially injurious substances in precipitation & dry particulate matter. Determine relative importance of precipitation & dry particulate matter. Develop optimum procedures. Determine stability of collection

or precipitation constituents. Investigate transport & transformations. Organize and coordinate research in SAES, FS & other institutions on the effects of atmospheric deposition on the productivity of agricultural crops, forests, range, wet lands & surface waters.

Approach: A program coordinator's office will be maintained to provide support for the NC-141 regional research project including project coordination, travel, special analyses and other project activities as needed by the regional research project. (This is to cover the RRF Off-the-Top Trust Fund to NC-141).

Progress: 82/01 to 82/12. Funds made available by the North Central Region of the State Agricultural Experiment Station (NC-141) and the U.S. Department of Agricultural CSRS are combined to support the coordination, data management and publications for the NC-141-sponsored program in atmospheric deposition referred to as the National Atmospheric Deposition Program (NADP). This support has been primarily directed to the establishment and coordination of a national atmospheric deposition monitoring network. Additional support has been obtained from other Federal agencies including BLM, EPA, USGS, USFS and NOAA, and a number of sites are supported by state agencies and private corporations. Since the beginning of the program in 1978, this monitoring network has expanded to 108 operating sites across the country, including Alaska and American Samoa. In 1983, NADP will become the core of the National Trends Network (NTN) which is being established under the mandated National Acid Precipitation Assessment Plan, with the addition of approximately 40 monitoring sites anticipated by 1984. Data published by the program now includes eight volumes covering data from July of 1978 through December of 1980. In addition, the monitoring data is available on computer tape either from the National Resource Ecology Laboratory, Colorado State University, or from the Environmental Protection Agency Data Management System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12

NO PUBLICATIONS REPORTED THIS PERIOD.

**07.006* CRIS0046521
FOREST METEOROLOGY AND AIR QUALITY**

FOX D G; USDA Forest Service, Ft Collins,
COLORADO 80521.
Proj. No.: RM-2110 Project Type: INHOUSE
Agency ID: FS Period: 13 AUG 80 to 03 OCT 84

Objectives: Develop methodologies that define and allow simulation of relationships between meteorological processes and forest and rangelands and encourage the incorporation of this information into land management planning activities. Current specific activities include outlining strategies for the management of air as a renewable natural resource and improving planning for the managed use of fire.

Approach: Through meteorological research, models and other tools will be developed to provide meteorological inputs into fire behavior and fire planning models applied to mountainous terrain in areas distant from weather stations. In addition, a decision process incorporating available and refined models of probable air pollutant movement, deposition and consequences in mountainous forests will be developed to aid Federal Land Managers in their responsibilities for reviewing PSD permit affecting Class I areas.

Progress: 80/08 to 84/09. A unique mountain climatology data base has been developed over four years with one-per-hour observations of meteorological variables on four different aspects and at three different elevations on Mount San Antonio, NM. Numerous observations of wind flows around the mountain have yielded information about the relationship between wind patterns and atmospheric stability. These data have established the validity of statistical models of mountain meteorology. Studies on the usefulness of meteorological information have developed analytical measures of the need for and location of meteorological monitoring. A system of computer models has been developed to aid air resource management decisionmaking. The Topographic Air Pollution Analysis System (TAPAS) includes topography data, two-dimensional and three-dimensional wind simulation models, dispersion models, and visibility impact assessment models. Also, TAPAS modules allow computer generated graphics map overlays (any map scale) of the model results. Utility of the system for operational decisionmaking has been demonstrated in the Bureau of Land Management and the Forest Service. Issues of model validity have been addressed culminating in work aimed at quantifying uncertainty in air quality model predictions. Growing recognition of the nondeterministic nature of the air quality modeling problem has led to better regulatory use of these tools.

Publications: 80/08 to 84/09

- FOX, D.G. 1984. Uncertainty in air quality modeling. Bull. Amer. Meteorol. Soc. 65(1):27-36.
- FURMAN, R.W., HAINES, D.A., and MILLER, D.R. 1984. Meteorology and climatology. In: Handb. of For., K.F. Wenger, editor. John Wiley & Sons, Inc. New York. 3:97-141.
- MURPHY, D.J., BUCHAN, R.M. and FOX, D.G. 1984. Ambient total suspended particulate matter and benzo(a)pyrene concentrations from residential wood combustion in a mountain resort community. Amer. Ind. Hyg. Assoc. J.
- RUNNING, S.W. 1984. Documentation and preliminary validation of H2OTRANS and DAYTRANS, two models for predicting transpiration and water stress in western coniferous forests. USDA Forest Service Res. Pap. RM-252, 45p.
- FOX, D.G. 1983. Part A. U.S. experience with air quality modelling. p. 4-156. In: Procs. of Air Quality Modelling Science and Regulation Workshop. Melbourne, Australia, August 17-18, 1983.

08.001 CRIS0069598
**RESPONSE OF AQUATIC LIFE TO ENVIRONMENTAL
 FACTORS AND WATER CONTAMINANTS**

KNIGHT A W; Land, Air & Water Resources;
 University of California, Davis, **CALIFORNIA**
 95616.
 Proj. No.: CA-D*-LAW-3075 Project Type: STATE
 Agency ID: SAES Period: 01 JUN 84 to 30 SEP 89

Objectives: To study the effects of environmental factors such as water temperature, salinity, dissolved oxygen, suspended matter, nutrients and surface water contaminants on aquatic life. The factors will be evaluated by employing growth, reproduction, scope for growth and acute and chronic bioassays. The organisms employed include opossum shrimp, bay shrimp, Asian clam, and aquatic insects.

Approach: Initial operations were directed at techniques for culturing aquatic organisms. Studies designed to evaluate the effects of environmental factors on aquatic life were developed more recently and include artificial streams, static and continuous flow bioassay systems, scope for growth systems, and systems for life cycle evaluation of aquatic animals. Techniques for placing aquatic organisms in select locations for evaluating wastewater and pollutants are under evaluation.

Progress: 82/01 to 83/12. Work conducted during this period consisted of both field and laboratory evaluations. In the laboratory we evaluated sediment-bound copper toxicity. Under a cooperative agreement with EPA we evaluated copper toxicity using the clam *Corbicula*, midge *Chironomus* and the amphipod *Corphium*. Tests, to date, include acute bioassays and long-term sublethal effects. We have developed suitable bioassay techniques for conducting sediment bound toxicity testing through most of the life stages of the test organisms. In the case of the midge we start with eggs and expose the insects through the life cycle including the stages of adult emergence and subsequent egg deposition and hatching. In the laboratory we have completed work necessary to prepare a scope for a growth model for the clam *Corbicula*. The model was prepared from physiological inputs and represents the clam responses to temperature over the range of 10 to 34 C. The scope for growth model will allow us to determine the effective of environmental factors or pollutants on the clam. We plan to evaluate other environmental factors such as salinity, food availability and herbicides as soon as possible. We have also studied the biological effects of acid deposition in cooperation with the National Park Service (acid rain studies program at Sequoia National Park) and the Cooperative Studies Unit at the University of California (Davis).

Publications: 82/01 to 83/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

08.002* CRIS0096764
**THE EFFECT OF ATMOSPHERIC DEPOSITION ON SOILS,
 PLANTS, AND WATERS**

REUSS J O; WALTHALL P M; LINDSAY W L;
 Agronomy; Colorado State University, Fort
 Collins, **COLORADO** 80523.
 Proj. No.: COLO0623 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 85 to 30 JUN 90

Objectives: To clarify the chemical processes that occur when soils are impacted by acid deposition, and the effects of these processes on the chemical composition of soil solutions and drainage waters. To evaluate the probability of deleterious effects occurring from current levels of deposition due to anthropogenic sources, the nature of such effects, their severity, and the time scale on which such effects are likely to be observed. To determine the probable effects of changes in current deposition levels, particularly acid deposition, on our soil, plant and water resources.

Approach: The general approach will involve a combination of theoretical studies using chemical models, and field and laboratory studies to evaluate the applicability of these models. Specific approach will include, but not be limited to, the following: 1. Development and testing of simple and accurate laboratory methods to determine input parameters required by current chemical models. 2. Field and laboratory testing of theoretical relationships utilized in chemical models. 3. Evaluation of cation replacement capacity of soil minerals. 4. Further model development, including refinement and expansion of current models and investigation of entirely different modelling approaches.

08.003* CRIS0100004
**ATMOSPHERIC DEPOSITION IN NATURAL ECOSYSTEMS OF
 THE WESTERN UNITED STATES**

FOX D G; Rocky Mountain Forest and Range
 Experiment Station; Colorado State University,
 Fort Collins, **COLORADO** 80523.
 Proj. No.: RM-2153 Project Type: INHOUSE
 Agency ID: FS Period: 01 OCT 84 to 30 SEP 89

Objectives: Create the basic knowledge needed to determine aquatic and terrestrial ecosystem effects resulting from specifically identified air pollution sources.

Approach: The research is sequentially structured to provide (1) protocols for quantifying physical and chemical environmental factors that influence aquatic and terrestrial ecosystems, (2) a better understanding of atmospheric delivery and ecosystem reception of air pollutants, and (3) knowledge of the biological effects caused by air pollutants introduced into ecosystems.

08.004* CRIS0089958
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

RIEKERK H; GHOLZ H L; CANFIELD D E; Forest Resources & Conservatn; University of Florida, Gainesville, **FLORIDA** 32611.
 Proj. No.: FLA-FOR-02321 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America, (Network Research), and to assess the effects of atmospheric deposition on land productivity, animal productivity, and water quality (Effects Research).

Approach: Network Research. Wet/dry fall collection stations in Florida in association with weather stations of ongoing research programs directly benefitting from the atmospheric deposition data. Weekly collection and sample shipment with weather data to, and return of data and synthesis reports from NADP central laboratory. Effects Research. Comparative importance of wet/dry fall on nutrient status of plants, soil and waters (Proj. Stat., A4). Effects wet/dry fall on forest nutrient cycling and forest tree growth (B1, 2). Influence on Al mobility and toxicity to fine tree roots (B6).

Progress: 83/10 to 84/09. Atmospheric deposition was monitored weekly at the Bradford Forest weather station in north-central Florida from Jan 1978 through Aug 1984. Acidity data from the first five years showed a highly significant drop of 0.2 pH units per year down to pH 4.6. Data from the sixth year initially followed the same trend but a reversal began after the summer of 1983 raising the average pH to about 5.0 during the summer of 1984. Plant nutrient inputs with rainfall during 1983 remained similar to that of the previous year and appeared to be significant for the longterm productivity of the sandy acid-leached pine flatwoods soils.

Publications: 83/10 to 84/09

RIEKERK, H. and KORHNAK, L.V. 1984. Environmental Effects of Silviculture in Pine Flatwoods. In 'Third Biennial Silvicultural Research Conference' Atlanta, GA, November 1984: (In press).

08.005 CRIS0014340
ECOLOGY OF FISH PRODUCTION IN MINNESOTA STREAMS

WATERS T F; Entomology, fisheries & Wildlife; University of Minnesota, St Paul, **MINNESOTA** 55108.

Proj. No.: MIN-41-072 Project Type: HATCH
 Agency ID: CSRS Period: 10 JUN 58 to 30 SEP 86

Objectives: Estimation of levels of production rate by various single-species fish populations in streams and rivers. Determination of effects of environmental variables on fish production rates. Measurement of fish population dynamics relevant to production. Special emphasis on

trophic ecology of fish as it affects production.

Approach: The instantaneous growth rate method will be used to obtain estimates of annual production by selected fish populations. environmental variables affecting fish production will be monitored in selected streams, including both natural perturbations such as floods and siltation and also environmental quality factors such as total alkalinity, pH, and nitrates of the water. All aspects of fish population dynamics--natality, survival, procedures. Trophic ecology of selected stream fish populations will be studied through fish stomach analyses (dissection or stomach pumping) and estimation of food organism abundance in the environment.

Progress: 84/01 to 84/12. The investigator returned from a sabbatical leave on March 15, 1984, completing field work for a book on the natural history of the North Shore of Lake Superior. Long-range studies on annual production by a stream trout population, initiated in 1965, were continued; this study will be terminated in April, 1985, concluding a 20-year set of population dynamics data. On the basis of this work, the investigator has been invited to participate in an international symposium on Fish Production in Streams, in Lodz, Poland, in September, 1985. Evaluation of the Valley Creek strain of rainbow trout was continued in the Clearwater River, Beltrami County; his project will be terminated in the next two years, and recommendations will be made to use this fish in management with special restrictive regulations. The acid precipitation-benthos study on three North Shore trout streams was completed in July, 1984; the results of this study, supported by Trout Unlimited, indicated that the three streams have not yet been affected. Two new projects were initiated during the past year, in connection with two new graduate students: 1) annual production and trophic ecology of a smallmouth bass population in a southeastern Minnesota stream (supported by Federation of Fly Fishers), and 2) population dynamics of an indigenous brook trout population in a small St. Croix River tributary, in conjunction with the Science Museum of Minnesota.

Publications: 84/01 to 84/12

NEWMAN, R.M. and WATERS, T.F. 1984. Size-selective predation on Gammarus pseudolimnaeus by trout and sculpins. Ecology 65:1535-1545.

WATERS, T.F. 1984. Annual production by Gammarus pseudolimnaeus among substrate types in Valley Creek, Minnesota. Am. Mid. nat. 112:95-102.

08.006 CRIS0094605
EVALUATION OF MITIGATION MEASURES FOR ACIDIC PRECIPITATION

GLOSS S P; SCHOFIELD C L; Natural Resources; Cornell University, Ithaca, **NEW YORK** 14853.
 Proj. No.: NYC-147343 Project Type: STATE
 Agency ID: SAES Period: 01 NOV 84 to 30 SEP 87

Objectives: To examine the variation in fish population response and effectiveness of liming over a range of acidic lakes with differing physical/chemical characteristics. To evaluate the success of restocking strategies using selected strains of fish. To provide interim management guidelines for lake liming.

Approach: The experimental segment of the project will involve selection of 10 candidate lakes in collaboration with NYSDEC. Selection criteria will include small size (e.g. 10-20 acres), a variety of hydrologic conditions to assess acidification rates, and remote location to minimize the effect of angler exploitation on evaluation of fish population responses. All lakes will be selected at the beginning of the study. The lakes will be limed (using one of the aforementioned dosing models) by aircraft in the fall and stocked with brook trout. Stocking time will be determined by short term toxicity tests following treatment. Paired stockings of selected and unselected strains of fall fingerlings will be made in each lake to evaluate relative strain survival. The lakes will be monitored daily following treatment (up to two weeks) for chemical changes (pH, Ca, Al) and comparison of predicted dissolution rates for the liming material made. Quarterly chemical samples will be collected thereafter.

08.007 CRISO091329
GENETIC ANALYSIS OF BROOK TROUT POPULATIONS

KRUEGER C C; Natural Resources; Cornell University, Ithaca, **NEW YORK** 14853.
 Proj. No.: NYC-147328 Project Type: STATE
 Agency ID: SAES Period: 01 SEP 83 to 31 DEC 83

Objectives: To describe the genetic variability within and among brook trout populations by gel electrophoresis.

Approach: An alternative scheme to traditional hatchery selection is to develop acid tolerant trout by first maximizing genetic variability by interpopulational hybridization and then challenging these fish in naturally acidified waters. Genetic variability in captive brook trout populations in New York and Ontario will be described as a first step.

08.008 CRISO092630
FISHERY/LIMNOLOGICAL RESEARCH COORDINATION

OGLESBY R T; GLOSS S P; SCHOFIELD C L; Natural Resources; Cornell University, Ithaca, **NEW YORK** 14853.
 Proj. No.: NYC-147408 Project Type: HATCH
 Agency ID: CSRS Period: 26 MAR 84 to 30 SEP 87

Objectives: Provide coordination and develop an overview of the several fishery and water quality monitoring projects in this Department related to effects of acid deposition on lakes

and mitigation of effects by liming.

Approach: Meetings will be held frequently to review approaches to problems and research progress both as the various projects (sponsored by EPA, USFWS, EPRI, State of New York) in this Department progress and as they relate to pertinent research being carried out by others in North America and Scandinavia. This will lead to a state-of-the-art overview and tentative conclusions concerning major research objectives being prepared as a written document by September 30, 1984.0.

Progress: 84/01 to 84/12. Investigators at this institution have been carrying out numerous separate studies on acid precipitation in New York's Adirondack Mountains and how the resultant acidification of lakes and streams affects fish populations and fish food organisms. This project provided coordination of these research efforts through combining information and facilitating communication. Specifically, data management and sharing, programming and scheduling of sampling and analytical work, and coordination of report preparation, were all enhanced by this project.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

08.009* CRISO070504
EFFECTS OF ACID PRECIPITATION ON ADIRONDACK LAKES

SCHOFIELD C L; GLOSS S P; WEBSTER D A; Natural Resources; Cornell University, Ithaca, **NEW YORK** 14853.
 Proj. No.: NYC-147321 Project Type: STATE
 Agency ID: SAES Period: 01 OCT 84 to 30 SEP 87

Objectives: To investigate lake and stream sensitivity to acidification by acid precipitation and determine the mechanisms which lead to chemical and biological changes. To evaluate and develop procedures for restoring and maintaining fisheries in acidified lakes.

Approach: Mechanisms of aluminum mobilization and transport to stream ecosystems and the biological effects of this acidification related process are being investigated at calibrated watershed sites in the eastern U.S. and Canada. Fish and invertebrate population responses to temporal and spatial acidification gradients within streams are being evaluated in the Adirondack Mountain streams. A pilot scale liming program (ELS, USFWS supported) was initiated on 10 Adirondack lakes in 1983. Limestone dose/alkalinity response functions, treatment longevity in relation to basin hydrology and morphometry, survival of stocked brook trout populations, and effects of neutralization on aluminum speciation and toxicity to trout are being evaluated. A companion lake liming study (LAMP, EPRI supported) was initiated on 3 Adirondack lakes to provide more detailed ecosystem level response data.

Progress: 84/01 to 84/12. Results of the ILWAS field program and lake acidification model development were summarized and submitted for publication as a series of papers in Water, Air, and Soil Pollution. Major findings of this four year field study of three Adirondack lake-watershed systems were: A primary determinant of lake alkalinity and sensitivity to acidification is the relative distribution of water inputs routed through shallow soil interflow and deeper, groundwater flow paths. Episodic acidification results from an upward shift in flowpaths from ground water dominated base flow to shallow interflow during increased snowmelt discharge. Increased acidity levels and aluminum mobilization during these events are triggered by increased nitric acid output and base cation dilution, relative to ambient sulfate levels. Model simulation of a 50% reduction in total atmospheric sulfur inputs indicated that significant decreases in acidity of sensitive Adirondack lake types would occur. Two lake neutralization studies were initiated in 1983 to evaluate the effects of liming and subsequent re-acidification on fish and invertebrate populations. Ten Adirondack lakes were treated and stocked with two strains of brook trout in 1983-84, to serve as a pilot scale evaluation of liming and the use of acid tolerant trout strains for rehabilitation of acidified Adirondack lakes.

Publications: 84/01 to 84/12

- GIBSON, J.N., GALLOWAY, J.N., SCHOFIELD C., McFEE, W., JOHNSON, R., McCARLEY, S., DISE, N., and HERZOG, D. 1983. Rocky Mountain Acidification Study. U.S. Fish and Wildlife Service, Division of Biological Services.
- SCHOFIELD, C.L. 1984. Surface water chemistry in the ILWAS basins. In: The Integrated Lake-Watershed Acidification Study Vol. 4: Summary of Major Results. R.A. Goldstein and S.A. Gherini, editors. EPRI Report EA-3221, pp.
- SCHOFIELD, C.L. 1984. Effects of acid deposition on aquatic systems. In: Acid precipitation in relation to agriculture, forestry, and aquatic biology. C.A. Black, editor. CAST Report No. 100, 31 pp.
- BAKER, J.P. and SCHOFIELD, C.L. 1984. Acidification impacts on fish populations: A Review. In: Acid Deposition: Environmental and Economic Impacts. D. Adams and W. Page, Editors. Plenum Publ. Co., NY (in press).
- SCHOFIELD, C.L., GLOSS, S.P., and JOSEPHSON, D. 1984. Extensive evaluation of lake liming, restocking strategies, and fish population response in acidic lakes following neutralization by liming.

08.010 CRIS0024544
DYNAMICS AND MANAGEMENT OF ADIRONDACK FISH POPULATIONS

WEBSTER D A; KRUEGER C C; SCHOFIELD C L;
Natural Resources; Cornell University, Ithaca,
NEW YORK 14853.
Proj. No.: NYC-147304 Project Type: STATE
Agency ID: SAES Period: 01 JUL 55 to 30 SEP 84

Objectives: To determine ways in which water chemistry and related factors (i.e. acid precipitation) limit fish production and to develop methods for increasing productivity for fish. To improve management options for production of brook trout (*Salvelinus fontinalis*) for angling through the use of wild and hybrid strains. To study and experimentally manipulate native and introduced fish populations to develop techniques for improvement of production of sport fisheries.

Approach: Addition of lime and superphosphate plus agitation of bottom sediments in selected instances, is evaluated by systematic measurements of appropriate physical and biological parameters. Domestic strains of brook trout are selected on basis of tolerance to acid runoff and progeny are mated to wild strain. F(1) is stocked in test waters with unselected control group. Potential forage fish (both native and non-native) have been introduced into trout waters to determine role in increasing maximum size of existing trout population, or existing native fish associations are being studied.

Progress: 84/01 to 84/12. Four year classes (1981-84 of paired plantings of selected acid-tolerant and appropriate control cohorts of hybrid brook trout were planted in 8 SW Adirondack lakes. Relative survival of the first 3 year classes was observed in 1982-84. The selected trout of the 1981 year class showed a substantially higher representation in 4 lakes (62:32% respectively) and 50:50 in the others (N=1100). Essentially no difference existed between cohorts in samples of the 1982-83 year classes (N=2100) indicating that between year differences in environmental stress may have been insufficient to cause differential survival. The lakes exhibited a wide range of environmental conditions of water chemistry, morphometry and flushing rate and correlation of survival with these parameters is not immediately apparent. Age at sexual maturity in salmonids varies with age, strain and environmental conditions. In the Adirondack study lakes it is usual for the majority of fish to pass age 1+ as juveniles. In 2 of the waters that remained continuously acidified nearly all trout reached maturity at this age, suggesting that stress might be exerting a strong influence on reproductive strategy. To test this hypothesis groups of laboratory reared hybrid yearling brook trout were subjected to both acute and chronic exposures (April-November) of naturally acidified runoff water.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

08.011 CRIS0097535
A BIOACOUSTIC MONITORING SYSTEM TO ASSESS FISH STOCKS IN SMALL PONDS

BRANDT S; Environ & Forest Biology; State
University of New York, Syracuse, NEW YORK
13210.
Proj. No.: NYZ-2652-01-004 Project Type: STATE
Agency ID: OCI Period: 01 JUL 85 to 30 APR 86

Objectives: To develop and test the feasibility of using an acoustic data acquisition and signal processing system for long-term monitoring of fish stocks in small lakes and ponds subject to acid precipitation.

Approach: Six lakes in the Adirondack ecological zone will be selected for bioacoustic study. Lakes will cover a range of types (size and depth). Low (70 Kh(z)), mid (120 Kh(z)) and high (420 Kh(z)) frequencies and wide, narrow and dual beam transducers will be tested and the relative advantages of each will be assessed with respect to lake type. The spatial distributions of fishes in acidic lakes will be examined in relation to morphology, temperature, pH, oxygen, time of day or season and a minimal sampling protocol to acoustically assess fish abundances with minimum variance will be recommended.

08.012 CRIS0094607
FORAGING AND REPRODUCTION OF THE COMMON LOON GAVIA IMMER ON ACIDIFIED AND NON-ACIDIFIED LAKES

BROCKE R; School of Biology Chem & Ecolo;
 State University of New York, Syracuse, NEW YORK 13210.
 Proj. No.: NYZ-2532-01-001 Project Type: STATE
 Agency ID: OCI Period: 01 MAY 84 to 30 APR 86

Objectives: To determine if the decline in the common loon (*Gavia Immer*) populations in Adirondack Park is caused by acid precipitation.

Approach: The investigator will examine the possible relationships between loon reproduction, loon foraging and lake acidification by comparing replicated data of three lake types varying in degree of acidification. The study lakes are centered in Essex, Hamilton and Herkimer counties within Adirondack Park.

Progress: 83/10 to 84/09. During May and June, 35 lakes were surveyed for loons and water pH. Study lakes were visited approximately 4 to 5 days each (15 lakes) during the summer. Information and data on dive times, foraging periods and activity and prey base were collected. Various water chemistry data were collected including conductivity, alkalinity and secchi depth.

Publications: 83/10 to 84/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

08.013* CRIS0000161
WATER, SOIL, AND AQUATIC RESPONSES TO MANAGEMENT OF SOUTHERN APPALACHIAN-PIEDMONT FORESTS

SWANK W T; SWIFT L W JR; WAIDE J B;
 Southeastern Forest Expt Station, Franklin,
 NORTH CAROLINA 28734.
 Proj. No.: SE-1651 Project Type: INHOUSE

Agency ID: FS Period: 17 MAR 76 to 09 OCT 86

Objectives: To evaluate and explain how water and aquatic resources respond to intensive management of Southern Appalachian and Piedmont forests and to identify management practices which protect these resources.

Approach: Basic and applied research will be conducted on forested plots and watersheds to determine the flux of water, nutrients, and pollutants and to relate these fluxes to productivity of terrestrial and aquatic ecosystems. From the knowledge gained from these studies, techniques for safely managing soil, water, and aquatic resources will be formulated and tested.

Progress: 83/10 to 84/09. Sulfate has been identified as a major constituent of acid precipitation in several regions of the United States. However, the fate of this exogenous sulfate in forest ecosystems is not well known. Recent studies at Coweeta Hydrologic Laboratory in the Southern Appalachians have shown that microbial populations in forest floor and soil rapidly metabolize inorganic sulfate into organic forms of sulfur. Annual rates of incorporation can exceed atmospheric inputs of sulfate and this process of organic sulfate formation accounts for part of the apparent sulfur accumulation in forest soils. Moreover, the presence of this biological pathway in the sulfur cycle of a forest provides a buffer against the impacts of acid precipitation on forest soils by reducing the mobility of sulfate, which in turn, reduces nutrient leaching. A comparison of water chemistry in white pine, pitch pine, and mixed hardwood forests showed that the forest canopy, litter, and upper 25 cm of soil are major compartments of ion exchange in each of these forests. Hydrogen ions delivered in acid precipitation are depleted within these compartments through exchange with other cations; by the time precipitation reaches the stream, pH values increase (less acid) nearly 2 pH units. These findings clearly illustrate the buffering influence of forests on substances derived from atmospheric deposition, such as acid precipitation.

Publications: 83/10 to 84/09

- SWANK, W.T., FITZGERALD, J.W. and ASH, J.T. 1984. Microbial transformations of sulfate in forest soils. *Science* 223:182-184.
- SWANK, W.T. and SWANK, W.T.S. 1984. Dynamics of water chemistry in hardwood and pine ecosystems. In: T.P. Burt and D.E. Walling (eds.) *Catchment experiments in fluvial geomorphology*, Proc. Int. Geogr. Union Comm. on Field.
- SWANK, W.T. 1984. Atmospheric contributions to forest nutrient cycling. *Water Resour. Bull.* 20:313-321.
- SINGER, F.J., SWANK, W.T. and CLEBSCH, E.E.C. 1984. Effects of wild pig rooting in a deciduous forest. *J. Wildl. Manage.* 48:464-473.
- BORING, L.R. and SWANK, W.T. 1984. Symbiotic nitrogen fixation in regenerating black locust (*Robinia pseudoacacia* L.) stands. *For. Sci.* 30:528-537.

08.014*

CRISO084308

ACUTE AND CHRONIC EFFECTS ON FISH EXPOSED CONTINUOUSLY AND INTERMITTENTLY TO TOXICANTS

CURTIS L R; WARREN C E; SEIM W K; Fisheries & Wildlife; Oregon State University, Corvallis, OREGON 97331.

Proj. No.: OREO0910 Project Type: STATE
Agency ID: SAES Period: 01 JUL 81 to 30 JUN 86

Objectives: The potential for environmental contaminants to produce adverse effects on natural populations is not easily extrapolated from laboratory data. Expanded knowledge of how temporal factors contribute to tolerance of fishes to toxic substances is necessary for development of environmental policy. The influence of manipulation of schedules of toxicant exposure on salmonid survival, growth and development will be studied.

Approach: The toxicity of copper and an additional agent to salmonids following continuous and intermittent exposure will be assessed. Juvenile rainbow trout will be utilized for determination of LC50 values, the results being coupled with 21 day growth studies. Embryo-larval tests will be conducted to ascertain the responses of another stage in the life history of rainbow trout to variation in exposure regimens of toxic substances. Tissue residue analysis will be utilized to gain insight into how dispositional factors may influence differential toxicity attributable to temporal aspects of exposure.

Progress: 83/01 to 83/12. Effects of cyclic exposures to environmental acidity on growth and survival of embryonic and larval brook trout (*Salvelinus fontinalis*) were studied. Exposure regimens were designed to model durations and frequencies of pH changes found in natural waters impacted upon by acidic precipitation. Experiments were conducted in a flow-through system in which water chemistry was rigidly controlled to maintain solute content within a range comparable with dilute surface waters where environmental acidification has occurred. Both short- and long-duration acidic conditions were tested to simulate acid rain and snow melt events, respectively. Five pH's between 4.0 and 6.8 were studied. Short-duration events (4.5 hr/day, 1 day/wk, 1 day in 4, 4 days in 8) occurred as repetitive cycles throughout the 70-day experiment. Long-duration events (2 wk) occurred once or twice over the course of the study at different life stages of the developing fish. In order to permit direct comparison between treatment regimen exposures were expressed as mean hydrogen ion concentration (H⁺) which animals experienced over the entire study. Results were compared to continue exposures at constant concentrations. For short and long-duration regimens more toxicity was attributable to intermittent than continuous exposures at equivalent (H⁺), except 4.5 hr/day.

Publications: 83/01 to 83/12

SHUBAT, P.J. and CURTIS, L.R. 1983. Influence of route of exposure on toxicity and accumulation of dieldrin in trout. Proc. West. Pharmacol. Soc. (ABSTRACT).

Submitted.

SIDDENS, L.K., SEIM, W.K., CURTIS, L.R. and CHAPMAN, G.A. 1983. Toxicity of environmental acidity on various life stages of brook trout. Proc. West. Pharmacol. Soc. (ABSTRACT). Submitted.
SEIM, W.K., CURTIS, L.R., SIDDENS, L.K. and CHAPMAN, G.A. 1983. Effect of varied exposure duration or toxicity of environmental acidity to developing salmonid embryos. Proc. West. Pharmacol. Soc. (ABSTRACT) Submitted.
CURTIS, L.R., SEIM, W.K. and CHAPMAN, G.A. 1983. Growth and survival of developing steelhead trout continuously or intermittently exposed to fenvalerate. Aquatic Toxicol. Submitted.

08.015

CRISO087657

IMPACT OF SURFACE WATER ACIDIFICATION ON IMPORTANT SALMONID FISHES

SCHRECK C B; LI H W; Fisheries & Wildlife; Oregon State University, Corvallis, OREGON 97331.

Proj. No.: OREO0914 Project Type: STATE
Agency ID: SAES Period: 01 MAY 82 to 30 APR 87

Objectives: Determine the sensitivity of commercially and recreationally important salmonids to surface water acidification as affected by recruitment failure. This goal will be addressed by determining the relative sensitivity of various reproductive and early life history stages of rainbow trout (a pH sensitive species) to reduced pH. The immediate research objectives are to: Quantify effects of reduced pH on adult rainbow trout reproductive physiology; and quantify effects of ambient acid on the survival and development of early life history stages.

Approach: A fall-spawning rainbow trout brood stock, both males and females, will be obtained from a local hatchery source. The brood stock will be divided into groups for exposure to a minimum of four nominal pH levels, ranging from about 4.5 to control (approximately neutral). Following acclimation of the fish to test tanks, the desired pH levels will gradually be attained by acidification with sulfuric acid. Exposure will commence approximately 2 months prior to spawning and will continue until the fish are ripe. Over the course of the prespawning exposure period, blood samples will be serially drawn from anesthetized fish for evaluation of circulating levels of plasma estrogens, androgens, corticoids, and calcium. When ripe fish will be manually spawned with fertilization to be performed in water of the appropriate pH level according to the scheme control female/control male; treatment female/control male; treatment male/control female.

Progress: 83/01 to 83/12. Adult rainbow trout were reared in waters of pH 4.5, 5, 5.5, and about neutral for approximately 2 months before spawning. Mating crosses indicated that eggs from females reared at the lowest pH were not as high a quality as those from parents raised under lower acidity. Further, fertilized

eggs incubated at pH 4.6 did not develop independent of acidification history of either parent. Blood factors such as estradiol and calcium associated with reproduction were not affected by acidification in any predictable manner.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

08.016 CRIS0076818
NATURAL PRODUCTION OF TROUT IN INFERTILE MOUNTAIN STREAMS OF PENNSYLVANIA

ARNOLD D E; Fisheries & Wildlife; Pennsylvania State University, University Park, PENNSYLVANIA 16802.

Proj. No.: PENO2408 Project Type: STATE
Agency ID: SAES Period: 01 MAY 79 to 30 JUN 84

Objectives: Determine factors which limit natural reproduction and growth of trout in infertile streams; develop methods to manipulate the limiting factors.

Approach: Compare fertile and infertile streams with regard to number and size of fish produced, effects of rainfall chemistry, and other factors. Test methods of managing and controlling the factors identified.

Progress: 79/05 to 84/06. The major objective has been to study and interpret the effects of acidification on aquatic systems, especially fish, and to study the ecology of trout streams in order to make fishery management techniques biologically sound. It was shown that streams exhibit many of the same consequences of acidification that have been reported for lakes, and that acidification affects all levels of the biological community, either directly or through the food chain. About 45% of the unpolluted waters studied in nine states were judged acidified or sensitive to acidification. In acidified streams, the insect community differs from that of neutral streams due to the absence of preferred species of plant life for food. Higher zinc levels and slower growth were characteristic of brook trout in acidic streams, perhaps due to food shortage. There seemed to be selection for increased survival of fry by providing more yolk per ovum under acidified conditions. An energy balance growth model was developed which illustrates how physiological and environmental constraints shape the behavior of drift-feeding salmonids.

Publications: 79/05 to 84/06

BACHMAN, R. A. 1984. Foraging behavior of free-ranging wild and hatchery brown trout in a stream. "Trans. Am. Fish. Soc." 113(1):1-32.

ZAK, M. A. 1984. Mass marking American shad and Atlantic salmon with the rare earth element, Samarium, M.S. Thesis. The Pennsylvania State University., University Park. 88p.

MILLER, J. D. 1985. Migration and drift of a stream amphipod, "Gammarus minus." M.S. Thesis. The Pennsylvania State University, University Park. in press.

08.017 CRIS0093509
STATUS AND EXPERIMENTAL MANAGEMENT OF FISH POPULATIONS WITH EMPHASIS ON ACIDIFICATION

CARLINE R F; ARNOLD D E; School of Forest Resources; Pennsylvania State University, University Park, PENNSYLVANIA 16802.
Proj. No.: PENO2750 Project Type: STATE
Agency ID: SAES Period: 01 JUL 84 to 30 JUN 88

Objectives: Determine species composition and standing crops of fish in selected watersheds; evaluate management practices to preserve or enhance fish populations; evaluate effects of acid precipitation on aquatic resources.

Approach: Studies dealing with experimental management of wild trout populations, fish behavior, and fish ecology will continue at PSU's Spruce Creek Experimental Fisheries Area. Waters sensitive to acidification will be studied to determine water chemistry and changes in biota attributable to acid precipitation. Experimental devices to neutralize and/or prevent acidity will be designed, constructed, and evaluated in several lakes and streams.

Progress: 84/07 to 84/12. Two small, low pH streams in central Pennsylvania were monitored to determine the status of macroinvertebrate and fish populations. Flow from major tributaries will be diverted through devices containing limestone in an attempt to neutralize the pH of these streams. Devices will be put in operation during the winter and spring of 1985 and effects on biota will be monitored throughout the year.

Publications: 84/07 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

08.018 CRIS0081386
FACTORS INFLUENCING TROUT PRODUCTION IN VIRGINIA STREAMS

PARDUE G B; BENFIELD E F; WEBSTER J R; Fisheries & Wildlife; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
Proj. No.: VA-1111114 Project Type: STATE
Agency ID: SAES Period: 01 JUL 80 to 30 JUN 85

Objectives: Examine links between the food production base and brook trout production, develop the work on brook trout competition with other age classes or trout and with nongame fish to include competition, determine rainbow trout production and gonadal energetics during the year.

Approach: Collect monthly quantitative samples of macroinvertebrates to determine trophic structure, biomass, production and feeding rates; collect quarterly depletion samples of fishes to determine trophic structure, biomass, production and food habits, compare food habits of trout with nongame fishes and examine longitudinal zonation of fishes in the stream, conduct quarterly mark-recapture sampling, collect length-weight data and use bomb calorimetry on somatic and reproductive tissues during the year.

Progress: 84/01 to 85/09. Studies assessing 1) differences in survival at low pH between hatchery strains of rainbow trout and 2) effects of low pH on disease resistance in Atlantic salmon fingerlings were completed. Five strains of rainbow trout at 5 life stages were tested in 96-hour LC50's, and complete mortality occurred at pH4.0. Progressively greater survival occurred in all strains as pH increased; wild fish were more tolerant than domesticated fish. Atlantic salmon fingerlings exposed to furunculosis in soft water at pH 5 had similar infection rates as those held in pH 6.5 after 21 days. Incidence of disease was not significantly affected by the pH levels tested. However, antibody levels in vaccinated fish were lower under acidic conditions, indicating that they are less resistant to the disease in acidic waters. Restoration of salmon in the Northeast may, therefore, be hindered by acid precipitation in that region.

Publications: 84/01 to 85/09

- BARNES, W. R., 1985, Survival of rainbow trout strains at low pH, Research Information Bulletin, U.S. Fish & Wildlife Service.
- LEE, E., 1985, The effect of acidified water on the susceptibility to infection by *Aeromonas salmonicida* and antibody production. In: Atlantic Salmon Fingerlings, Research Information Bulletin, U.S. Fish and Wildlife Service.
- PORTER, P. E., 1985, Comparison between the subsurface environment of brown trout redd and nonredd sites in two North Carolina streams, M.S. Thesis, Virginia Tech, Blacksburg, Va.
- BRAYTON, S. and NEVES, R. J., 1985, Reproductive cycle & associated changes in energy content of body tissues in rainbow trout from the South Fork Holston River, Va., Proc. 36th Annu. Conf. S.E. Assoc. Fish & Wildl. Agencies 358-368.

10.001 CRIS0081457 DISEASES OF PEACHES, PECANS AND APPLES

HENDRIX F F; POWELL W M; Plant Pathology & Plt Genetics; University of Georgia, Athens, GEORGIA 30602.
Proj. No.: GE000711 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 80 to 30 JUN 85

Objectives: To study the etiology of *B. obtusa* on apple; and determine effective chemical and cultural controls for *B. dothidea* and *G. cingulata*. Study the etiology of gummosis on peach. Investigate the use of systemic pesticides for the control of pecan root diseases. Investigate other diseases of these and related crops as needed.

Approach: Standard phytopathological procedures will be followed where applicable in identifying and controlling disease agents on fruit and nut crops. For new diseases, laboratory tests will be used to determine effectiveness of available chemicals. Research will be continued to establish minimum pesticide usage. Air will be monitored for pollutants and tests carried out in fumigation chambers in an effort to reproduce symptoms. New technology and techniques for application and evaluation of pesticide will be devised and tested.

Progress: 84/01 to 84/12. Diseases of blueberry were surveyed in Georgia. Botrytis blight is currently causing economic losses. Anthracnose is present but is not currently a problem. Mummy berry exists only in the northern third of the state. Experiments were started to control Botrytis blight. Work was completed on control of black rot of apple with a SAT using 3500 ml/ha of Difolatan. Work with the tree row volume spraying is being continued. Gummosis of peach trees is caused by *Botryosphaeria obtusa*, *B. dothidea* and *B. rhodina*. *B. obtusa* is found in cankers primarily in the winter, and *B. dothidea* and *B. rhodina* in the summer and fall.

Publications: 84/01 to 84/12

- BEISEL, M., HENDRIX, F.F., and STARKEY, T.E. 1984. Natural inoculation of apple buds by *Botryosphaeria obtusa*. *Phytopathology* 74:335-338.
BRITTON, K.O. and HENDRIX, F.F. 1984. Population dynamics of fungi in peach gummosis cankers. *Phytopathology* (abstract).
HENDRIX, F.F., JR. and BRITTON, K.O. 1983. Evaluation of apple fungicides, 1981. *Fungicide and Nematicide Tests* 38:139.
SMITH, M.B. and HENDRIX, F.F., JR. 1984. Primary infection of apple buds by *Botryosphaeria obtusa*. *Plant Disease* 68:707-709.

10.002* CRIS0090671 PHYSIOLOGY, BIOCHEMISTRY, AND BEHAVIOR OF ECONOMICALLY IMPORTANT PHYTOPHAGOUS INSECT SPECIES

ALFORD A R; Entomology; University of Maine, Orono, MAINE 04469.
Proj. No.: ME08506 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: Insure physiological synchrony of spruce budworm by identifying growth parameters and behavioral or morphological markers for precise staging of test larvae. Monitor the endocrine events of spruce budworm and blueberry maggot growth, development, and diapause. Examine the host selection processes involved in the chemoreception and ovipositional site selection by adult female spruce budworm moths and blueberry maggot flies, emphasizing the effects of environmental factors.

Approach: Critical head-capsule width and body weights and behavioral or morphological markers (such as changes in body position, coloration, ocelli movement and molting) will be identified in spruce budworm larvae. Juvenile hormone esterase activity will be measured as the conversion of JH acid in the haemolymph. Timing of release of prothoracicotropic hormone and ecdysone will be performed through neck and thoracic-abdominal ligature experiment, respectively. Chemoreceptors involved in the host selection and recognition by the females will be identified and characterized using ablation and electrophysiological techniques. Effects of inter-related physical, chemical and biological factors on their receptivity will be investigated.

Progress: 83/10 to 84/09. The alkaline-dissolved *Bacillus thuringiensis israelensis* (BTI) -endotoxin was injected into the abdomen of *Trichoplusia ni*. In vivo recordings of activity in the ventral nerve cord indicated that BTI -endotoxin elicited hyperexcitability and then nerve death; these symptoms are similar to those resulting from the organophosphorous compound, methamidophos. The effects of low pH (acid precipitation) on growth and development of the caddisfly *Pycnopsycha guttifer* were examined under laboratory conditions. The most critical life stage was the pupa; over 70% and 60% of pupae exposed to pH 3.5 and 4.5 respectively, failed to develop successfully to adults. Larvae exposed to pH 3.5 and 4.5 suffered significant loss of synchrony in their development and took considerable longer to pupate. Spruce budworm larvae reared under constant temperature (20 C) pupated five to seven days prior to and with less temporal variability than larvae reared under fluctuating temperatures (10 /20 C). There were no observed differences in diurnal molting patterns between the two rearing regimes.

Publications: 83/10 to 84/09

- ALFORD, A.R., and SILK, P.J. 1984. Behavioral effects of secondary components of sex pheromone of western spruce budworm (*Choristoneura occidentalis*) *Free. Journal of Chemical Ecology* 10: 265-270.

SILK, P.J., KUENEN, L.P.S., TAN, S.H., ROELOFS, W.L., SANDERS, C.J., and ALFORD, A.R. 1984. Identification of sex pheromone components of the jack pine budworm, *Choristoneura pinus pinus* Freeman. *Journal of Chemical Ecology* 10.

ROE, R.M., CHEUNG, P.Y.K., HAMMOCK, B.D., BUSTER, D., and ALFORD, A.R. 1984. The toxicity and nervous response from *Bacillus thuringiensis israelensis* -endotoxin in mice and insects: evidence for broad-spectrum neurotoxicity.

10.003 CRIS0066186
CROP AND ORNAMENTAL PLANT TOLERANCE TO SULFUR DIOXIDE AND OZONE AIR POLLUTANT EXPOSURE

BOOTH J A; Entomology & Plant Pathology; New Mexico State University, Las Cruces, NEW MEXICO 88003.

Proj. No.: NM-1-3-42220 Project Type: STATE
Agency ID: SAES Period: 01 JUL 82 to 30 JUN 84

Objectives: Complete studies now in progress re. effects of SO_2 on pecan nut quality. Determine differences in susceptibility to ozone SO_2 , and mixtures of the two among commercial cultivars of alfalfa, chile pepper, and cotton. Identify and isolate pollution tolerant individuals through selections from large populations of alfalfa representing many cultivars.

Approach: Pecan nut quality alterations resulting from exposure to 3.0 ppm-hrs of SO_2 will be determined by measurement of nut weight, volume, density, meat wt., meat protein and liquid quantity. Treatments will be made biweekly throughout the 1982 season. Large numbers of plants of cultivars of alfalfa, cotton and chile pepper will be exposed to SO_2 , ozone, and mixtures of the two gases in order to identify those which show tolerance to one or both of the gases. Vegetative propagation of tolerant lines will be used to isolate promising germ plasm for use in genetic improvement programs. The technique of convert sulfit to sulfate. Vegetative propagation will be used to isolate promising germ plasm for use in improvement programs.

Progress: 84/01 to 84/06. On December 20, 1983 the greenhouse housing the SO_2 treatment facility, and all of the isolated selections of alfalfa which showed some degree of tolerance to SO_2 exposure, were lost in a fire. In the subsequent months, especially considering the high cost of replacement of the facility, the decision was made to terminate this project and change the research direction. Existing data which was complete enough for publication was assembled, and at this point in time it appears that two manuscripts having to do with SO_2 effects on pecan nut retention and quality will be submitted for journal publication. The alfalfa SO_2 -tolerance research had not progressed sufficiently for publishable data to be accumulated.

Publications: 84/01 to 84/06

NO PUBLICATIONS REPORTED THIS PERIOD.

10.004 CRIS0074284
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY IN THE NORTHEAST

KENDER W J; MUSSELMAN R C; Pomology & Viticulture; N Y Agriculture Expt Station, Geneva, NEW YORK 14456.
Proj. No.: NYG27485 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Determine physiological, biochemical and morphological mechanisms of susceptibility and resistance of plant cultivars to air pollutants and to determine whether these are affected by interactions with biotic factors in the environment. Identify the genetic mechanism of resistance of plant cultivars to air pollutants. Develop air pollutant resistant plant material.

Approach: Vineyard and laboratory fumigation studies will be conducted at Geneva, N. Y. and Fredonia, N. Y. Progenies from crosses will be evaluated to study inheritance patterns associated with oxidant stipple. The influence of rootstock, nitrogen nutrition, water status, stomatal resistance, and pollutant interactions on oxidant stipple of grapevines will be examined.

Progress: 77/10 to 82/09. In the same year of fumigation, oxidant stipple on Concord grape leaves was increased on vines receiving both continuous at .10 and .05 ppm and episodic levels of SO_2 plus ambient air. This indicated SO_2 was a synergistic agent increasing ozone injury. As a result, soluble solids were reduced. Continuous SO_2 at .10 ppm ambient air for 2 consecutive years reduce yield and vine growth in year 2, 3 and 4 and was related to the degree of induced leaf injury and chlorosis. Continuous SO_2 plus ambient air at .05 ppm caused yield reductions in year 2. Measurements are now being made for year 3. Also sulfur dioxide injury symptoms were observed in all sulfur dioxide-fumigated vines. Only in 1981 were these symptoms observed under ambient conditions (a year with high levels of ambient SO_2). Oxidant stipple - protectant studies revealed that low concentrations of benomyl provided protection that was related to the frequency of application. Other antioxidants were not effective. Commercial application, for oxidant stipple only, is questionable. Acid rain studies on apples and grapes revealed that rain acidity at current ambient levels, pH 4.2 - 4.4, has no detrimental effect on productivity.

Publications: 77/10 to 82/09
FORSLINE, P.L., R.C. MUSSELMAN, R.J. DEE, and W.J. KENDER. 1982. Effects of acidic rain on grapevines. *Amer. J. Enology & Vitic.* (accepted for publication).
KENDER, W.J. and P.L. FORSLINE. 1982. Remedial measures to reduced air pollution losses in horticulture. *HortScience.* (accepted for Publication).

FORSLINE, P.L., R.C. MUSSELMAN, W.J. KENDER, and R.J. DEE. 1982. Effects of acidic rain on apple tree productivity and fruit quality. J.Amer. Soc. Hort. Sci. (accepted for publication).

WEINSTOCK, L., W.J. KENDER, and R.C. MUSSELMAN. 1982. Microclimate within open top air pollution chambers and its relation to grapevine physiology. J. Amer. Soc. Hort. Sci. (Accepted for publication).

10.005 CRIS0076833
ENVIRONMENTAL AND GENETIC FACTORS ASSOCIATED WITH THE DEVELOPMENT OF THE GENUS VITIS

SMITH C B; GREENE G M; HAESELER C W;
 Horticulture; Pennsylvania State University,
 University Park, PENNSYLVANIA 16802.
 Proj. No.: PEN02427 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 79 to 31 DEC 84

Objectives: Determine the effects of mineral nutrition on vine growth, fruit yield and quality. Determine the response of Vitis to various cultural techniques. Ascertain the influence of various climatic factors on production, fruit quality and vine development. Select genetically superior clones and cultivars of Vitis.

Approach: Subject grape plants to wide range of nutritions. Vines will be subjected to various pruning severities and training systems, rootstocks, grafting techniques, irrigation practices, growth regulation and herbicides. Those varieties or clones that appear superior in or consistent producers will be tested under the various ecological conditions of Pennsylvania. Climatic variables will be studied and various measures will be recorded. Air pollution factors will also be studied with respect to grape production. All trials will be properly replicated.

Progress: 79/07 to 84/12. Production of several table grape cultivars commenced fruiting this past year in Erie County. Initial production in a plant spacing experiment with Concord grapevines trained to the GDC system came into bearing, also, this past season. Initial results with an herbicide-sucker control growth regulator were very encouraging both from the standpoint of weed and sucker control as well as cost of control. A new preemergence herbicide for control of grasses was very effective for the second year in succession. It, also, was effective and non-phyto toxic in young, non-bearing vineyards. Use of combinations of Diuron and Princep at half rates were not as effective as one or the other used at the full rate alone. Application of foliar applied nutrients in the form of Bayfolan Plus were not particularly impressive after the second year. Quality analyses - soluble solids, pH, total acidity, sodium and potassium concentrations - were made for 40 cultivars this past season. Tests with the growth regulator Pix were not impressive in enhancing fruit set or in affecting yield, quality or growth of the vines in Erie or Lancaster counties. Use of growth regulators to enhance fruit size and to thin some

tight-clustered cultivars did show promise.

Publications: 79/07 to 84/12

HAESELER, CARL W. 1984. Experiences with wine grapes in Pennsylvania. Proc. Arkansas State Horticultural Society 104:153-156.

HAESELER, CARL W. 1984. Characteristics of several wine grape cultivars under southern Pennsylvania conditions. Proc. Pennsylvania Wine Conference. 17:78-84.

HAESELER, CARL W. 1984. The production of grapes for juice in Pennsylvania: Its research - past, present and future. Proc. Arkansas State Horticultural Society. 104:

10.006* CRIS0076369
SOIL FERTILITY, MANAGEMENT, AND PLANT NUTRITION FOR FORAGE AND HORTICULTURAL CROP PRODUCTION IN EAST TEXAS

HABY V A; Research & Extension Center; Texas A&M University, Overton, TEXAS 75684.
 Proj. No.: TEX06320 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 83 to 30 JUN 88

Objectives: Determine the influence of varying levels of soil acidity on the availability of soil and applied fertilizer nutrients for roses and warm and cool season grasses and legumes. Evaluate the efficiency of applied N and that fixed by leguminous plants for small grains and warm season grass production. Evaluate the influence of K fertilizers on disease reduction in small grains and Coastal bermudagrass. Determine the soil fertility and fertilizer requirements of blueberries and peaches under East Texas conditions. Determine the effect of acid rain on East Texas soils and crops. Relate crop responses from various plant nutrient applications to the soil test level of those nutrients in order to improve the predictability of the soil test for fertilizer needs.

Approach: Field studies on bench mark soils of East Texas will be used to evaluate the responses of soils and crops to fertilizer nutrients and limestone. Greenhouse research will support the field studies. Soil and plant analyses in the laboratory will help evaluate field and greenhouse experiment responses. Data will be evaluated by appropriate statistical analyses.

Progress: 84/01 to 84/12. Ryegrass yield responses to limestone rates of 0, 672, and 3810 kg/ha were 3119, 5063, and 6020 kg/ha, respectively. Yields increased from 4120 to 5629 kg/ha as P rate increased from 0 to 240 kg/ha, respectively. Winter wheat grain yield increased from 1463 to 4016 kg/ha with N rate increments from 0 to 224 kg/ha, respectively, but yield differences due to the N sources ammonium nitrate, urea, and urea phosphate were negligible. Prior year growth of subterranean clover contributed the equivalent of 70 kg N/ha to the wheat. Winter wheat grain yields were similar for KCl and K(2)SO(4) potassium sources. Yield response to K rate increases was not statistically significant. A versatile, three-point hitch, tractor-mounted applicator was designed and constructed to dispense fluid

fertilizers from containers pressurized by a tractor-mounted and powered pressure system. This applicator is used to evaluate dribble band spacings, methods of application, rates, and combinations of fluid fertilizers applied to Coastal bermudagrass. A severe summer drought restricted growth but grass yield from the three harvests was significantly increased from 11,500 to 15,928 kg/ha as N rate increased from 45 to 135 kg/ha at site one, and from 8064 to 10,080 at site two which is a less responsive soil. Banded urea-ammonium nitrate at spacings of 18, 36, 53, and 71 cm between bands, and method of application had no significant effect on grass yield. Nitrogen source comparisons yielded mixed results between both sites.

Publications: 84/01 to 84/12

- NELSON, L.R., HABY, V.A., BATEMAN, C. and KREJSA B. 1984. Accumulation of Al, Ca, Mg, Mn, K and P in annual ryegrass due to soil flooding. American Society of Agronomy Abstracts.
- BRANDT, J.E., HONS, F.M. and HABY, V.A. 1984. The effect of nitrogen management on the yield and nitrogen uptake efficiency of soft red winter wheat. American Society of Agronomy abstracts.
- HABY, V.A., DAVIS, J.V. and SMITH, K.L. 1984. A versatile fluid fertilizer applicator for field research. American Society of Agronomy Abstracts.

CM 11 POTATOES

11.001 CRIS0012304
PHYSIOLOGICAL ASPECTS OF CROP HARDINESS

LI P H; Horticultural Science and Landscape Architecture; University of Minnesota, St Paul, MINNESOTA 55108.
 Proj. No.: MIN-21-074 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 90

Objectives: To elucidate the cold acclimation mechanism in tuber-bearing *Solanum* potatoes & winter spinaches. To investigate the effects of mefluidide protection on post-application growth & development, & on ABA metabolism in chilled maize. To characterize the heat adaptability in the common bean.

Approach: In combination with the use of specific RNA/protein synthesis inhibitor plants growing in a stem-cultured system will be cold acclimated, & proteins from acclimated plants will be extracted & analyzed by SDS-PAGE technique. The effects of mefluidide on corn seed germination under chilling conditions, post-application growth & development, water relations & ABA metabolism will be examined. Experiments planned include the characterization of heat adaptability in common bean germplasm, a comparative study of photosynthesis, & study of the development of reproductive structures between high & low heat adaptable genotypes.

Progress: 83/01 to 83/12. A computerized open-top field exposure chamber system was used to examine the effects of ozone, sulfur dioxide and their mixture on soybean yield. The pollutant exposure regimes simulated the ambient patterns in Minnesota. Numerical analyses showed that log, exponent, sine, arcsine transformations and other related approaches could not satisfactorily explain the relationships between the pollutant exposures and the measured plant parameters. In cooperation with Alberta Government and Scientists, a polynomial - fourier model was successfully developed to explain the pollutant - plant response relationships. For the first time in the literature, this model accounts for the number of pollutant episodes (any concentration above the detection limits); the size (mathematical area under the exposure) of each individual episode and the peak pollutant concentration in each episode. Using this model, soybean pod number, pod weight, seed number, and seed weight were successfully accounted ($r = 0.90$) for the various pollutant treatments.

Publications: 83/01 to 83/12
 NOSAL, M. and KRUPA, S.V. 1983. A mathematical model to relate air quality to crop response. J. Air. Pollut. Control Assoc. In Press.
 LEGGE, A.H. and KRUPA, S.V. 1983. Air pollutants and their effects on the terrestrial ecosystem. John Wiley and Sons. NY. In Press.

11.002 CRIS0083305
BREEDING AND EVALUATION OF NEW POTATO CLONES AND VARIETIES IN THE NORTHEAST AREA

PISARCZYK J M; Horticulture; Ohio Agric Res and Devip Center, Wooster, OHIO 44691.
 Proj. No.: OH000706 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 80 to 31 MAR 83

Objectives: To determine regional performance, quality, and storage characteristics of promising potato clones and new varieties and evaluate promising clones and new varieties for special purpose needs such as unusual pest outbreaks, processing, export, and/or production situations.

Approach: Field performance of selected clones and new varieties will be determined in specially established replicated plots grown according to recommended commercial practices. Data will be collected as to plant and tuber characteristics, yield, and size distribution of tubers. Responses of promising clones and new varieties to naturally occurring air pollutants (ozone) will be recorded.

Progress: 80/10 to 83/03. Of thirteen varieties tested in 1980, the highest yielding varieties in MT/ha. U.S. No. 1 tubers were Katahdin (43.2MT) and BR7093-23 (42.0 MT). The varieties with highest specific gravity were BR7088-18 (1.072), CD106-16 (1.070), and BR5991-WV16 (1.069). Russette, CD 106-16, and W564-3A did not produce acceptable color chips. Hollow heart was high in B7583-6 (20%) and CA02-7 (10%). Internal necrosis was high in BR5991-WV16 (57%), BR7088-48 (30%), Katahdin (27%), and W564-3A (27%). Of nineteen varieties tested in 1981 the highest yielding varieties in MT/ha. of U.S. No. 1 tubers were CC26-1A (42.3 MT), Superior (33.5 MT), Katahdin (33.2 MT), and CF7358-26 (32.7). The varieties with highest specific gravity were CC26-1A (1.086), CF7358-14A (1.085), and Norchip and AF238-4 at 1.087. All varieties produced acceptable color chips. There was no hollow heart and only three varieties had internal necrosis--Katahdin (7%), BR5991WV16 (7%), and B6043-WV6 (3%). Of eighteen varieties tested in 1982, the highest yielding varieties in MT/ha. of U.S. No. 1 tubers were F73008 (53.5 MT), BR5991-WV16 (51.5 MT), and Acadia Russet (46.9) MT). The varieties with the highest specific gravity were Denali (1.100), BR5991-WV16 (1.092), and CF7353-1 (1.091). All varieties produced acceptable color chips except Acadia Russet. Hollow heart was found in Denali (10%) and CF7353-1, CC26-1A, and B8934-4 each with 3%. Internal necrosis was found in three varieties--BR5991-WV16 (17%), Acadia Russet (3%), and Denali (3%).

Publications: 80/10 to 83/03
 NO PUBLICATIONS REPORTED THIS PERIOD.

11.003

CRIS0092464

PHYSIOLOGY OF WHEAT AND POTATOES

MOSS D N; Crop Science; Oregon State
University, Corvallis, OREGON 97331.
Proj. No.: ORE00390 Project Type: HATCH
Agency ID: CSRS Period: 01 MAR 84 to 31 DEC 88

Objectives: Define physiological traits limiting yield and those useful in breeding high yielding varieties of wheat and potatoes.

Approach: Studies will be conducted at various levels of plant organization (molecular, subcellular, cellular, tissue, organ, plant, community). The information will be summarized in a logical framework using the power of modern computers. Data from a lower level will generally be used in models to predict response at the next higher level of organization.

Progress: 84/01 to 84/12. The primary task under this project this year has been to analyze and summarize data from several years study on the effects of acid rain on field crops. Neither wheat nor potatoes showed any yield reduction when the crops were exposed to simulated acid rain in the pH range 3.5 to 5.5. Maize was the only field grown crop which showed any effect of acid rain on yield. Maize had a suppressed yield at pH 4.0 in two of three years. The most extensive experiments on maize were done in 1982, and there was no effect on yield of any treatment in that year. We concluded that acid rain is not likely to be a significant problem for crop plant production, and the fertilizer elements (S and N) contained in the rain may enhance yields in poorly fertilized crops.

Publications: 84/01 to 84/12

MOSS, D.N. 1984. Photosynthesis, respiration and photorespiration in higher plants. In Physiological Basis of Crop Growth and Development. American Society of Agronomy, Madison, WI.

CM 12 VEGETABLES

12.001 CRISO089797 GENETIC EFFECTS OF FLUORIDE ON SELECTED PLANT SPECIES

SAPRA V T; SHARMA G C; SHUFORD J W; Natural Resources & Env Studis; Alabama Agric and Mech Coll, Normal, ALABAMA 35762.
Proj. No.: ALAX-3-40-14-3150 Project Type: STATE
Agency IO: OCI Period: 10 SEP 80 to 10 AUG 84

Objectives: To study the effect of different concentrations of fluoride on mitotic and meiotic cell division in corn and tomatoes, and study the mutagenic effects and reproduction incompatibilities induced by toxic levels of fluoride.

Approach: Two plant species, corn and tomatoes (sensitive to hydrogen fluoride) were studied under controlled environmental growth chambers. Plants were exposed to both air and soil application of fluoride at different concentration. Genetic effects of fluoride was studied in first generation exposed to air and soil borne fluoride. Mitotic and meiotic cell division was studied. Mutagenic effects was judged by observing morphological characteristics in fluoride treated plants. The estimation of fluoride in air was measured by ion specific electrodes.

Progress: 84/01 to 84/08. In 1983-84, a study on the effect of fluoride on tomato plant was undertaken in a fumigated growth chamber on two tomato varieties (Fluorodale and Campbell 37). Three levels of HF rates (0, 16, 30 g/ , three durations (4, 8, 12 days) were used on three-week-old tomato seedlings. The results showed foliar fluoride injury developed on tomato plants receiving all of the HF treatment combinations, except plant receiving four days exposure at 16 mu g/m showed no injury. Post-fumigation analyses of tomato plants and fruit for fluoride showed that increase in HF rate from 16 mu g/m to 30 mu g/m significantly fluoride content in 4-week plant, 14-week plant and tomato fruit. According to our previous results on corn, HF gas can induce significant chromosomal aberrations in mitosis and meiosis, but in the present study tomato reacted differently. Chromosomal abnormality was found at 16 mu g/m of 4-day treatment in variety Florodale.

Publications: 84/01 to 84/08

- WANG, J.K. 1983. Mutagenic effects of gaseous hydrogen fluoride on maize. M.S. Thesis. Alabama A&M University, Normal, AL.
WANG, J.K., SAPRA, V.T. and SHARMA, G.C. 1983. Mutagenic effects of gaseous hydrogen fluoride on maize. Int. Congress of Genetics, New Delhi, India. Part I. p. 344.

12.002 CRISO084091 EFFECTS OF SO(2) AND OZONE ON GROWTH, PRODUCTIVITY, PHYSIOLOGY AND BIOCHEMISTRY

LAUCHLI A W; TIMM H; YANG S F; Inter Departmental; University of California, Davis, CALIFORNIA 95616.
Proj. No.: CA-D*-XXX-4108-H Project Type: HATCH
Agency IO: CSRS Period: 12 MAY 81 to 30 SEP 86

Objectives: To determine the effects of SO(2) and ozone on several varieties of field crops and vegetable differing in resistance to these air pollutants, in terms of growth, productivity, mineral nutrient uptake and osmotic relations of the plants, biochemical studies on lipid metabolism and ethylene production as related to SO(2) sensitivity, and to investigate the interactions between SO(2) and ozone stress and salinity.

Approach: Exposure to the air pollutants will be done in an environment-controlled chamber. SO(2) and ozone will be applied singly or in combination, and also in combination with salt stress. Growth will be measured as germination, emergence, root growth, and by protein analysis. Effects on nutrition will be assessed by ion transport experiments using radiotracers and measurement of inorganic and organic solutes. Stomatal apertures will be monitored with a diffusion porometer. The biochemistry of SO(2) injury will be determined by measuring production of ethane and ethylene and by following oxidation of SO(2) by sulfite measuring production of ethane and ethylene and by following oxidation of SO(2) by sulfite oxidase.

Progress: 84/01 to 84/12. Low level effects of SO(2) on tomato, alfalfa and cucurbits were studied. Germination of seed and pollen was unaffected, but root growth of tomato seedlings was extremely retarded by SO(2).(-) Cucurbit roots were less SO(2) sensitive. Root growth appears SO(2) sensitive because of HSO(3) formation in the medium. Pollen tube growth of all tested species was inhibited by SO(2). Effects of low level ozone pollution on growth and yield of beans were studied in the field using open-top field chambers. Two chamber designs were tested. Two-blower chambers were more effective in maintaining temperatures similar to ambient in the presence of plants than were one-blower chambers. Photosynthetically active radiation (PAR) was reduced by 20% within the chambers compared to ambient. Ozone variability in the chambers was only slight. Data on physiological parameters, growth and yield of beans under low-level ozone fumigation are being analysed. Initial results showed that "Blue Lake" bean growth was inhibited by 5 hr. daily fumigations with 0.06-0.08 mu O(3). A comprehensive final report for Air Resources Board is in preparation.

Publications: 84/01 to 84/12

- TIMM, H. and BARNES, K. 1984. Pollen germination and tube growth responses to low level SO(2) exposure. Hort Science 19(3)72.

12.003 CRISO140463 AIR QUALITY STUDIES ON INDIANA MELONS

HECK W W; SIMON J; WILCOX G; Horticulture; Purdue University, West Lafayette, INDIANA 47907.
Proj. No.: 6645-20790-002-02S
Project Type: COOPERATIVE AGREE.
Agency ID: ARS Period: 21 MAY 84 to 31 DEC 87

Objectives: To conduct studies that quantitatively determine the extent and impact of air pollution damage to the melon plant, the melon crop and indicator plants in southwest Indiana. To determine the potential for utilizing host plant resistance to tolerate poor air quality conditions. 3) Develop methodologies for identification of secondary nitrogen compounds which accumulate in plant tissues during maturation in order to reduce compounds related to smoking and health.

Approach: To utilize selected plant varieties in the melon area as indicator plants to measure the time, extent, duration of SO₂(2), O₃(3), and NO₂(2) damage to the indicator plants, as well as the melon crop. To monitor at selected sites the amount of air pollution and associate it with damage symptoms and effects on the growing melon crop. To test available melon varieties and germplasm to ascertain the degree of tolerance to existing air quality conditions in the field. The tests to be run in exposure chamber systems.

12.004 CRIS0048472
EVALUATION OF EXTENT AND EFFECT OF AIR POLLUTANTS ON CUCURBIT CROP

REED D K; MOSER B; Lynnwood-purdue Agric Center; Purdue University, West Lafayette, INDIANA 47907.

Proj. No.: 3690-20221-010-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 31 JUN 84 to 21 JUN 87

Objectives: 1. Determine the extent and nature of air pollutants in melon areas. 2. Determine the effect of pollutants on melon plants. 3. Establish relative tolerance of existing melon varieties to pollutants. 4. Continue evaluations of foundation germplasm as basis for tolerant varieties.

Approach: 1. Computer operated pollution monitoring devices will be located in two areas in SW Indiana to monitor SO₂, O₃ particulates and acid rain. 2. Biological indicator plants will be planted at 5 locations in the melon area. Open top chambers will be used as budget allows to allow monitoring of plants grown under filtered air. 3. Observations will be made of melon hybrids adapted for commercial production in the midwest. 4. Lines of the National Muskmelon group will be evaluated as part of normal research.

12.005* CRIS0047438
EVALUATION OF RISK FROM LEAD AND OTHER HEAVY METALS PRESENT IN URBAN GARDEN & SMALL FARM SOILS

CHANEY R L; USDA Agricultural Research Service, Beltsville, MARYLAND 20705.

Proj. No.: 1203-20793-009-00D
 Project Type: INHOUSE

Agency ID: ARS Period: 27 OCT 81 to 21 MAR 84

Objectives: Develop soil sampling and analysis methods for high metal urban soils; characterize metal sources for urban garden soils and their impact on high-risk crops; determine whether sludge compost or other amendments can prevent accumulation of soil Pb by lettuce; and determine whether amendments can reduce the availability of soil Pb to animals fed soils containing excessive Pb.

Approach: Evaluate methods for soil analysis on high metal soils with varied chemical properties; Evaluate methods of sampling community gardens; conduct a survey of Baltimore gardens to characterize the extent and sources of garden soil metal pollution; measure metal content of leafy vegetable crops sampled in urban gardens; conduct pot studies to determine whether phosphate fertilizer, limestone, or sludge compost can reduce metal uptake by leaf and root vegetables; conduct soil feeding trials with rats to assess bioavailability of soil Pb from different pollution sources, and whether soil amendments can reduce this bioavailability.

Progress: 81/10 to 84/04. Results from our survey of heavy metals in garden soils in Baltimore, MD were analyzed using a new statistical procedure which calculates the probability of Pb concentration in mapping units. Both automotive Pb emissions and Pb paint residues contributed to high accumulation of Pb in inner city soils. These results were published, and the journal prepared an editorial discussing these results. Soil-plant metal relationships in Baltimore gardens research results have been incorporated into manuscripts which are undergoing review.

Publications: 81/10 to 84/04
 MIELKE, H.W., ANDERSON, J., BERRY, K., CHANEY, R.L., LEECH, M.L. and MIELKE, P.W. 1983. Lead concentration in inner city soils as a factor in the child lead problem. Am. J. Public Health.
 CHANEY, R.L., and STERRETT, S.B. 1982. The potential for heavy metal exposure from urban gardens. In Symposium on Heavy Metals in Urban Gardens. University of the District of Columbia.

12.006* CRIS0074071
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

MANNING W J; FEDER W A; Plant Pathology; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00435 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors.

Approach: Whole plant responses of tolerant and sensitive cultivate cultivated plants and forest trees will be identified and used to determine responses to ozone and sulfur dioxide. Plant indicators of air pollution will be determined and used to determine air quality through development of dose/response cures. Work will continue on ozone and sulfur dioxide effects on root disease and nodulation of legumes. The effects of elevated heavy metal content of soils on plant sensitivity to pollutants will be determined. Work will begin on acid rain/gaseous air pollutant interactions.

Progress: 83/10 to 84/09. Set up ozone monitoring at Arnold Arboretum, Boston, MA about 10 miles east of Suburban Experiment Station in Waltham, MA. This allowed us to measure air quality on site of the Harvard University, Arboretum large lilac variety collection where leaf roll symptoms have been observed for many years. We could then compare air quality at Waltham and at the Arboretum. Both sites had very similar air quality patterns during summer of 1984. High and prolonged ozone episodes occurred at both sites during late June, early July 1984. Values ranged from 0.1-0.2 ppm for at least 4 hours daily for as long as 3-6 days at a time. Leaf roll symptoms occurred later in the summer at the Arboretum on supposedly ozone-susceptible varieties of lilacs. The degree of injury seemed to relate to ambient ozone levels at the Arboretum. Greenhouse lilacs exposed to schronic low levels (0.06-8ppm) for 5 hrs/day for 5-8 weeks developed flecking and glazing symptoms. Typical leaf roll necrosis symptoms developed on *Syringia vulgaris* cv Marie Legraye, Miss Ellen Willmot, and Primrose, but only bronzing occurred on cv Congo. This conformed data obtained the previous winter. A complicating factor may be what appears to be feeder root deterioration in the lilacs growing at the Arboretum. I suspect a nematode problem and we will look at this as soon as the ground thaws next spring.

Publications: 83/10 to 84/09

DAMICONE, J.P., MANNING, W.J. and FEDER, W.A. 1984. Effects of ozone and *Fusarium oxysporum* alone and in combination on growth early maturing soybean lines. *Phytopathol.* 74 (7):843.

COLLEY, D.R., MANNING, W.J. and FEDER, W.A. 1984. Differences in alfalfa cultivar sensitivity to ozone. *Phytopathol.* 74 (7):843.

12.007* CRIS0082978
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS &
MATERIALS

FEDER W A; CRAKER L E; Suburban Exper Station; University of Massachusetts, Waltham, MASSACHUSETTS 02154.

Proj. No.: MAS00496 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils.

Approach: In addition to maintaining 2 NADP/IR7 collection sites, studies of the plant/soil/air rainfall interactions will be made to discover if atmospheric deposition predisposes plants to injury by foliar or root pathogens/pests and if plant injury is enhanced or reduced by inter-actions between atmospheric deposition and other air pollutants like ozone, sulfur dioxide, and/or particulate matter. The effects of changes in soil chemistry from atmospheric depositions upon mycorrhizal and nitrogen fixation organisms will be examined. The changes in soil chemistry due to atmospheric deposition will be studied for their effects on the mobilization of toxic elements like Al and the subsequent effects of released aluminum upon aquatic ecosystems. The movement of trace heavy metals from atmospheric deposition through terrestrial ecosystems will be followed and the effects quantified.

Progress: 83/10 to 84/09. Continued to operate wet/dry collectors for NADP network. Also participated in state-wide survey of aquatic lake/pond/stream pH values and fairly high alkalinity values, indicating little rainfall effect upon pH of aquatic areas surveyed. Soil solution pH rather than rainfall pH controlled movement of heavy metals through two soil types. Agriculturally, soil chemistry and soil solution chemistry will regulate the magnitude of the acid rainfall effect on plants growing in any soil. This seems to confirm the fact that crop plants growing in good agricultural soils properly cared for culturally will not be adversely affected by acid precipitation, per se. It is important to appraise farmers of this information, while at same recognizing that the ction of acid rainfall over forest ecosystems may have a different impact, of which to date, we have little understanding. This project will be continued under a new Hatch Project Number, as of October 1, 1984.

Publications: 83/10 to 84/09

MIKA, J. S. and WILLIAM A. F. 1984. The movement of incinerator fly ash and residue-generated Cd, Pb and Zn through soil columns leached with acid precipitation, APCA Northeast Atlantic International Section Technical Meeting.

12.008 CRIS0041828
DISEASE CONTROL AND VARIETY IMPROVEMENT OF DRY
BEANS IN THE NORTH CENTRAL STATES

SAETTTLER A W; Forage Research Unit; USDA Agricultural Research Service, East Lansing, MICHIGAN 48824.

Proj. No.: 3930-20020-001-00D

Project Type: INHOUSE
 Agency ID: ARS Period: 15 NOV 74 to 15 NOV 83

Objectives: Develop high yielding varieties of navy (pea), red kidney, cranberry and large white beans resistant to anthracnose, ozone

damage, bean common mosaic virus, and several bacterial blight diseases. Investigate the epidemiology of the bean bacterial diseases and develop improved methods for detecting seed borne infections. Determine the effects of cultural practices on incidence of Fusarium root rot and ozone damage. Develop cultural, biological and chemical disease control methods.

Approach: Identify strains of anthracnose, bean common mosaic virus and bacterial blight. Testing breeding and advanced lines for disease resistance in greenhouse and field plots. Evaluate selections for disease resistance, agronomic performance and quality factors prior to epidemiological studies in the greenhouse and field; adapted selective media and serological techniques to detect seed borne blight bacteria. Evaluate cultural, biological and chemical disease control methods in greenhouse and field. Conduct greenhouse and field studies on cultural control of Fusarium root rot and ozone damage.

Progress: 83/01 to 83/12. Severe outbreaks of angular leaf spot (*Isariopsis griseola*) were noted during 1982 and 1983 in Michigan seed fields of the Montcalm dark red kidney bean cultivar. Seed harvested from infected fields carried both external and internal contamination by *I. griseola*; contaminated seed gave rise to infected seedlings in greenhouse studies, thus confirming seed transmissibility of *I. griseola*. Of the several classes of dry edible beans, red kidney and cranberry were very susceptible to the pathogen, while black turtle soup, navy and pinto were resistant. All twenty-one (21) isolates of anthracnose, *Colletotrichum lindemuthianum*, obtained from infected plant materials during the period 1979-82 were identified as race alpha. Dominant single gene resistance to alpha and delta races of anthracnose has been introduced into erect, narrow profile navy and black bean genotypes. Thirty-two (32) isolates of *Pseudomonas syringae* pv. *phaseolicola*, indigenous to diverse bean production zones of Malawi were separated into 4 pathogenicity groups using 6 bean cultivars. The same 32 isolates yielded 5 serotypes based on heat stable antigens; however, there was no correlation between serology and pathogenicity group. Dark red kidney cv. Montcalm exhibited tolerance to all 2 isolates of Psp, plus known U.S. "races" 1 and 2.

Publications: 83/01 to 83/12

MORALES, M.A. 1983 Identification of necrosis-inducing strains of bean common mosaic virus and breeding for resistance. M.S. Thesis, Michigan State Univ., E. Lansing. 81 p.

PONTIUS, L.T. 1983. In vitro and in vivo inhibition of bacterial and fungal pathogens of beans by bacterial antagonists. M.S. Thesis, Michigan State Univ., E. Lansing. 89 p.

RUBIN, B., PENNER, D., and SAETTLER, A.W. 1983. Induction of isoflavonoid production in *Phaseolus vulgaris* L. leaves by ozone, sulfur dioxide and herbicide stress. Environmental Toxicology and Chemistry 2:295-306.

SAETTLER, A.W. and HART, L.P. 1983. Bean Anthracnose. Ext. Bull. E-1671. Mich. State Univ., E. Lansing. 2 pp.

12.009*

CRIS0012304

PHYSIOLOGICAL ASPECTS OF CROP HARDINESS

LI P H; Horticultural Science and Landscape Architecture; University of Minnesota, St Paul, MINNESOTA 55108.

Proj. No.: MIN-21-074 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 90

Objectives: To elucidate the cold acclimation mechanism in tuber-bearing *Solanum* potatoes & winter spinaches. To investigate the effects of mefluidide protection on post-application growth & development, & on ABA metabolism in chilled maize. To characterize the heat adaptability in the common bean.

Approach: In combination with the use of specific RNA/protein synthesis inhibitor plants growing in a stem-cultured system will be cold acclimated, & proteins from acclimated plants will be extracted & analyzed by SDS-PAGE technique. The effects of mefluidide on corn seed germination under chilling conditions, post-application growth & development, water relations & ABA metabolism will be examined. Experiments planned include the characterization of heat adaptability in common bean germplasm, a comparative study of photosynthesis, & study of the development of reproductive structures between high & low heat adaptable genotypes.

Progress: 83/01 to 83/12. A computerized open-top field exposure chamber system was used to examine the effects of ozone, sulfur dioxide and their mixture on soybean yield. The pollutant exposure regimes simulated the ambient patterns in Minnesota. Numerical analyses showed that log, exponent, sine, arcsine transformations and other related approaches could not satisfactorily explain the relationships between the pollutant exposures and the measured plant parameters. In cooperation with Alberta Government and Scientists, a polynomial - fourier model was successfully developed to explain the pollutant - plant response relationships. For the first time in the literature, this model accounts for the number of pollutant episodes (any concentration above the detection limits); the size (mathematical area under the exposure) of each individual episode and the peak pollutant concentration in each episode. Using this model, soybean pod number, pod weight, seed number, and seed weight were successfully accounted ($r = 0.90$) for the various pollutant treatments.

Publications: 83/01 to 83/12

NOSAL, M. and KRUPA, S.V. 1983. A mathematical model to relate air quality to crop response. J. Air. Pollut. Control Assoc. In Press.

LEGGE, A.H. and KRUPA, S.V. 1983. Air pollutants and their effects on the terrestrial ecosystem. John Wiley and Sons. NY. In Press.

12.010* CRIS0066186
**CROP AND ORNAMENTAL PLANT TOLERANCE TO SULFUR
 DIOXIDE AND OZONE AIR POLLUTANT EXPOSURE**

BOOTH J A; Entomology & Plant Pathology; New Mexico State University, Las Cruces, **NEW MEXICO** 88003.

Proj. No.: NM-1-3-42220 Project Type: STATE
 Agency ID: SAES Period: 01 JUL 82 to 30 JUN 84

Objectives: Complete studies now in progress re. effects of SO(2) on pecan nut quality. Determine differences in susceptibility to ozone SO(2), and mixtures of the two among commercial cultivars of alfalfa, chile pepper, and cotton. Identify and isolate pollution tolerant individuals through selections from large populations of alfalfa representing many cultivars.

Approach: Pecan nut quality alterations resulting from exposure to 3.0 ppm-hrs of SO(2) will be determined by measurement of nut weight, volume, density, meat wt., meat protein and liquid quantity. Treatments will be made biweekly throughout the 1982 season. Large numbers of plants of cultivars of alfalfa, cotton and chile pepper will be exposed to SO(2), ozone, and mixtures of the two gases in order to identify those which show tolerance to one or both of the gases. Vegetative propagation of tolerant lines will be used to isolate promising germ plasm for use in genetic improvement programs. The technique of convert sulfites to sulfate. Vegetative propagation will be used to isolate promising germ plasm for use in improvement programs.

Progress: 84/01 to 84/06. On December 20, 1983 the greenhouse housing the SO(2) treatment facility, and all of the isolated selections of alfalfa which showed some degree of tolerance to SO(2) exposure, were lost in a fire. In the subsequent months, especially considering the high cost of replacement of the facility, the decision was made to terminate this project and change the research direction. Existing data which was complete enough for publication was assembled, and at this point in time it appears that two manuscripts having to do with SO(2) effects on pecan nut retention and quality will be submitted for journal publication. The alfalfa SO(2-) tolerance research had not progressed sufficiently for publishable data to be accumulated.

Publications: 84/01 to 84/06
 NO PUBLICATIONS REPORTED THIS PERIOD.

12.011* CRIS0006306
**ORIGIN, TRANSFORMATION, AND MANAGEMENT OF
 NITROGEN IN SOILS, WATERS, AND PLANTS**

ALEXANDER M; HICKS J R; MINOTTI P L; Agronomy; Cornell University, Ithaca, **NEW YORK** 14853.
 Proj. No.: NYC-125457 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 DEC 83

Objectives: Establish and characterize factors governing gains and losses of nitrogen, particularly nitrate in soils, waters and plants.

Approach: The kinetics of denitrification and the ecology of the responsible microorganisms will be investigated. The possibility of nitrosamine formation during nitrate metabolism in natural habitats will be studied. Selected nitrate-accumulating vegetables will be studied after harvest to suggest practical handling methods which maintain high quality and minimize nitrate loss with subsequent nitrate accumulation. Emphasis will be placed on the effects of temperature, atmospheric composition, physiological age, plant species, variety, nitrogen fertilization and contamination. The role of microorganisms and plant enzymes will be considered.

Progress: 83/01 to 83/12. Nitrification and N mineralization were inhibited by rain at pH 3.5 or 4.1 applied in 26 d at normal rates (8.3 cm per month). Application of 3 or 9 times ambient rates in 26 d still inhibited the oxidation of added ammonium. Mineralization was inhibited only in soil treated with pH 4.1 rain at 9 times the ambient rate of precipitation. Simulated acid rain suppressed nitrification but not N mineralization after application for 56 d at 6 times the normal rate. Samples of the organic horizon (O2) of an Adirondack soil treated with rain at pH 3.5 containing the usual concentrations of heavy metals lost 10 percent more inorganic N than soil treated with rain containing no heavy metals. In soil treated with pH 5.6 rain, the loss of inorganic nitrogen was 5 percent greater in soils not receiving heavy metals than those in which the rain contained the heavy metals. N mineralization and nitrification rates were measured in soil samples after treatment with simulated rain at pH 3.5 or 5.6 had ended. In these soils treated with pH 3.5 rain, mineralization and nitrification were less in soil treated with the heavy metals. At pH 5.6, mineralization was greater and nitrification was slower in soil receiving the heavy metals. To determine which soils are more sensitive to acid rain, 12 soils with a range in pH and organic matter levels and texture were exposed to rain at pH 5.6, 4.0 and 3.5.

Publications: 83/01 to 83/12

KLEIN, T.M., KREITINGER, J.P. and ALEXANDER, M. 1983. nitrate formation in acid forest soils of the Adirondacks. Soil Sci. Soc. Am. J. 47:506-518.

CHANG, F.H. and ALEXANDER, M. 1983. Effects of simulated acid precipitation on growth and nodulation of leguminous plants. Bull. Environ. Contam. Toxicol. 30:379-387.

CHANG, F.H. and ALEXANDER, M. Effects of simulated acid precipitation on decomposition and leaching of organic carbon in forest soils. Soil Sci., in press.

KLEIN, T.M., NOVICK, N.J., KREITINGER, J.P. and ALEXANDER, M. Simultaneous inhibition of carbon and nitrogen mineralization in forest soil by simulated acid precipitation. Bull. Environ. Contam. Toxicol., in press.

12.012 CRIS0097557
THE EFFECTS OF ATMOSPHERIC POLLUTANTS ON THE REPRODUCTION OF AGRICULTURAL CROPS

DUBAY D; STUCKY J; NEAGLE A; Botany; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.

Proj. No.: NC09340 Project Type: CRGO
 Agency ID: CRGO Period: 01 SEP 85 to 30 SEP 87

Objectives: Proj 8501684. Determine the direct effects of simulated acid reproduction of corn, soybean, wheat, cotton, snap bean, and tomato, determine the influence of chronic O(3) exposure on the effects of acid rain on cotton and soybean reproduction. Determine the effects of acid rain on the viability and fitness of seeds produced by treated flowers.

Approach: Flowers are exposed once to simulated rain of different acidities. Cotton and soybean are grown before and after rain treatment in chambers with charcoal-filtered air or air with added D(3). Treated flowers are scored for seed production, and seeds are tested for viability and fitness.

12.013 CRIS0094516
GENETICS AND BREEDING OF GREENHOUSE TOMATOES

BERRY S Z; Horticulture; Ohio Agric Res and Devlp Center, Wooster, **OHIO** 44691.

Proj. No.: OH000781 Project Type: HATCH
 Agency ID: CSRS Period: 24 OCT 84 to 30 SEP 89

Objectives: Conventional plant breeding will be used to develop new tomato cultivars adapted to greenhouse culture with the following attributes: increased yield, improved fruit quality, multiple disease resistance, ability to set fruit at reduced temperature and light (also parthenocarpy), and insect and air pollutant resistance. New advances in the field of biotechnology, tissue culture, pollen culture, and cell selection techniques will be utilized.

Approach: Actual breeding and preliminary evaluations will be done in Center greenhouses and fields. Where expedient, tomato germplasm from public, and private sources, will be collected and utilized in the breeding program. The backcross and pedigree breeding methods will be used. Open pollinated lines, and formulated hybrids, will be evaluated in Center greenhouses and then advanced to trial in commercial greenhouses. Seed increase of the most promising lines and hybrids will be arranged for, along with release to the industry.

12.014 CRIS0082223
INTERACTIONS BETWEEN SULFUR DIOXIDE (SO(2)) AND EARLY BLIGHT IN TOMATO

DAVIS D D; Plant Pathology; Pennsylvania State University, University Park, **PENNSYLVANIA** 16802.

Proj. No.: PEN02521 Project Type: HATCH
 Agency ID: CSRS Period: 01 FEB 81 to 31 DEC 83

Objectives: To determine if SO(2) influences the disease cycle of early blight of tomato and the quality and quantity of fruit yields.

Approach: Tomato plants will be exposed to SO(2) in the laboratory or in the field, and inoculated with *Alternaria solani*. The influence of SO(2) alone, *Alternaria* alone, and interactions will be studied in terms of tomato yield.

Progress: 81/02 to 83/12. The combined exposure to SO(2) and infection by "*Alternaria solani*" resulted in a decrease in tomato fruit number and an increase in mean individual weight of remaining fruit. In a second experiment, ripe fruit harvested from plants exposed to SO(2) exhibited a slight but significant decrease in ascorbic acid expressed on a dry-weight basis. SO(2) induced significantly greater levels of foliar sulfur, but did not increase sulfur content of the fruit. Exposure of plants to SO(2) did not affect tomato fruit yield, soluble solids, total solids, or ascorbic acid on fresh-weight basis.

Publications: 81/02 to 83/12

LOTSTEIN, R.J., DAVIS, D.D. 1983. Influence of chronic sulfur dioxide exposures on early blight of tomato. Plant Dis. 67:797-800.

LOTSTEIN, R.J., DAVIS, D.D., PELL, E.J. 1983. Quality of tomatoes harvested from plants receiving chronic exposure to sulfur dioxide. HortScience 18(1):72-74.

LOTSTEIN, R. J. 1982. Effects of SO(2) on tomato fruit quality and plant susceptibility to "*Alternaria solani*". M.S. Thesis. Penna. State Univ., 41 pp.

12.015 CRIS0066860
AIR POLLUTANTS ON CROPS--PROTECTIVE MECHANISMS FOR OZONE RESISTANCE

FONG F; Plant Science; Texas A&M University, College Station, **TEXAS** 77843.

Proj. No.: TEX06119 Project Type: HATCH
 Agency ID: CSRS Period: 02 SEP 75 to 07 MAR 84

Objectives: Determine levels of lipid peroxidation in bean leaves during ozone treatment. Characterize enzymatic and non-enzymatic lipid peroxide detoxification mechanisms and their regulation in bean leaves. Determine if Methomyl and Diazinon can modify activity of detoxification mechanisms.

Approach: The proposal outlines a series of investigations which will initially identify one or two possible lipid peroxide detoxification mechanisms in higher plants. The

studies will then focus on a) how these mechanisms vary during leaf development, and b) if they are affected by various chemical treatments which modify ozone sensitivity of leaves. The use of chemicals to modify ozone sensitivity will enable a careful dissection of the injury process as well as provide an indication of those biochemical characteristics which may be amenable to regulation at the chemical and genetic levels.

Progress: 83/01 to 83/12. Trifluralin treatment of bean seedlings results in significant protection of the foliage against ozone injury. Total nonstructural carbohydrate increases three fold following trifluralin treatment of bean plants. We have begun to investigate the basis for this large increase in carbohydrates, as well as their ultimate fate. The large pool of soluble carbohydrates in trifluralin-treated plants is completely metabolized within two hours of an ozone fumigation period. It is probable that these sugars are used in a repair process. We are currently testing the hypothesis that the initial increase in carbohydrates is caused by mild water stress. Various osmotically active polymers are being used to establish a graded series of water-stress treatments. Bean seedlings exposed to these stress treatments are being monitored to determine if the carbohydrate content changes caused by water stress can account for trifluralin induced changes.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

12.016 CRIS0096693
EVALUATION OF BEAN GERMLASM FOR RESISTANCE TO ATMOSPHERIC DEPOSITION OF AIR POLLUTANTS

RANGAPPA M; HECK W W; DUNNING J; Agricultural Research Station; Virginia State University, Petersburg, VIRGINIA 23803.
Proj. No.: VAX-521251 Project Type: 1890/T
Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 90

Objectives: Evaluate bean; *Phaseolus vulgaris* accessions for O(3) resistance; based on sensitivity to O(3), selected accessions will be evaluated for SO(2) resistance. Evaluate yield effects of selected low and high sensitive accessions under chronic O(3) exposures to determine sensitivity patterns as to acute exposures to O(3). Expose selected accessions to SO(2) and to Mixture of O(3), SO(2), and NO(2) as appropriate. Investigate mechanisms of resistance to air pollutants; O(3) and SO(2) on low and high sensitive accessions and study differences in physiological, biochemical and Nutritional parameters as appropriate. Monitor atmospheric deposition at both field sites (VSU and NCSU) for use in predicting atmospheric influences and bean production.

Approach: Phytotrons and open-top field chambers will be used in evaluations of about 4,000 bean accessions. Extensive plant agronomic data will be collected in both phytotrons and field experiments. Will work out

mechanisms of resistance by using selected low and high sensitive accessions. Biochemical and nutritional components of those selected accessions will be analyzed. Will monitor atmospheric deposition at both field sites.

12.017 CRIS0078648
GENETIC MEANS OF CONTROL OF RESISTANCE OF BEANS TO AIR POLLUTANTS

BENEPAL P S; RANGAPPA M; DUNNING J; Office of The Director; Virginia State University, Petersburg, VIRGINIA 23803.
Proj. No.: VA.X-521141 Project Type: 1890/T
Agency ID: CSRS Period: 11 JAN 79 to 30 SEP 85

Objectives: Locate sources of genetic resistance of beans to air pollutants, determine the effect of air pollutants on biochemical attributes of beans. Study mechanism of resistance, establish and maintain germ plasm sources resistant to air pollution.

Approach: The bean germ plasm will be screened under controlled environmental conditions and in the field for resistance to air pollutants especially ozone, and sulfur dioxide. Laboratory air pollution exposures will be made in a continuous stirred tank reactor system. Plants with less than 10% injury will be selected and further tested under field conditions in open top air pollution chambers with ambient air and with charcoal filters. The effect of air pollutants on productivity, and nutritional quality (protein, amino acids, carbohydrates, crude fiber etc.) will be studied. The various morphological and chemical features of resistant and susceptible plants will also be studied to determine the mechanism of resistance. Promising germ plasm will be shared with other interested scientists.

Progress: 84/01 to 84/12. In 1984, 1186 plant introductions (P.I.'s) of beans (*Phaseolus vulgaris*) were screened in phytotrons at NCSU, Raleigh, N.C. for resistance to acute ozone (O3), concentrations of 0.06 ppm O(3) for 2 hours. 82 accessions were resistant to O(3) (less than 35% visible injury). In addition, 58 of the most O(3) resistant accessions were further screened for resistance to sulfur dioxide (SO(2)) concentrations of 1.5 ppm SO(2) for 1.5 hours. 42 accessions were resistant to SO(2) (less than 35% visible injury). The effects of O(3)-SO(2) gas mixtures on six accessions of *P. vulgaris* were determined at NCSU, using open-top field exposure chambers. Three different concentrations of O(3) were combined with four different concentrations of SO(2) to produce 12 different O(3)-SO(2) treatments, which were repeated three times. Screening for resistance of *P. vulgaris* to chronic O(3) exposures was performed in open-top field exposure chambers at VSU, Petersburg, VA. Two *P. vulgaris* crops (spring and fall), consisting of seven accessions each, were exposed to six different O(3) concentrations, which were repeated three times. Agronomic data, including yield and biomass were recorded at both field

locations (NCSU and VSU). Climatic conditions, including minimum and maximum temperature, humidity, and precipitation, were recorded daily.

Publications: 84/01 to 84/12

- REINERT, R., DUNNING, J.A., RANGAPPA, M., BENEPAI, P.S., and HECK, W.W. 1984. Screening of bean (*Phaseolus vulgaris*) for sensitivity to ozone. HortScience: volume 19: 86:88.
- GADE, W., RANGAPPA, M. and GROSS, P. 1984. Nutritional characteristics of zone tolerant accessions of beans (*Phaseolus vulgaris*) Fifth Biennial Research Symposium October 22-26, page 34.
- RANGAPPA, M., GROSS, P., DUNNING, J.A., REINERT, R.A. and HECK, W.W. 1984. Systematic evaluation of beans (*Phaseolus vulgaris*) Germplasm for genetic resistance to air-pollutants. Fifth Biennial Research Symposium October 22-26,

12.018 CRIS0032022
GENETIC IMPROVEMENT OF PHASEOLUS VULGARIS POPULATIONS FOR QUALITY, PRODUCTIVITY AND STRESS TOLERANCE

BLISS F A; Horticulture; University of Wisconsin, Madison, **WISCONSIN** 53706.
 Proj. No.: WISO1626 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 88

Objectives: 1) Develop improved breeding methods for common bean and other self-pollinated crops, 2) Identify new sources of and utilize existing genetic variation for improving plant architecture, efficiency of di-nitrogen fixation, tolerance to temperature extremes, moisture and air pollutants, seed protein and disease resistance, 3) Study genetic variation for the above traits and incorporate favorable genes into improved bean germplasm, and 4) Release improved populations, breeding lines and cultivars.

Approach: The approach is to utilize the inbred backcross line method to transfer traits from exotic germplasm, effectively transfer genes controlling quantitative traits, and to develop stable disease resistant populations. Field and greenhouse screening will be used to identify and utilize new sources of variability for the traits emphasized. Classical genetic analyses will be made to determine the inheritance of genes controlling useful levels of those traits. Improved germplasm will be developed and released to other commercial and public breeders.

Progress: 84/01 to 84/12. The inbred backcross line method is being used routinely to incorporate genetic variability for quantitative traits into commercially usable snapbean and drybean germplasm. Improvement of snapbeans includes the following traits; plant architecture, N(2)-fixation potential, and field resistance for the root rot complex, bacterial brown spot and Sclerotinia white mold. Improvement of dry beans includes traits for plant architecture, seed yield, percentage protein, N(2)-fixation and field resistance to

root rot. Five near homozygous snapbean breeding lines were released as germplasm to seed companies. These included U.W. 84-G6-6, U.W. 84-G5-5, U.W. 84-G4-2, U.W. 84-G4-8 and U.W. 84-G4-11. These lines resulting from a cross 15R-55 x (WCBT 713938 x Tempo), were selected for their high levels of field resistance to the Wisconsin root rot complex and desirable horticultural traits. Ten breeding lines of small white navy and 13 breeding lines of black dry beans were released as germplasm to seed companies. These lines were selected for high percentage seed protein, and increased N(2)-fixation potential in addition to acceptable commercial grain type.

Publications: 84/01 to 84/12

- ESTRADA, S., MUTSCHLER, M.A. and BLISS, F.A. 1984. Temperature-influenced instability in a genic male sterile common bean. HortScience. 19:401-402.
- BLISS, F.A. 1984. The application of new plant biotechnology to crop improvement. HortScience. 19:43-48.
- NCHIMBI, S. 1984. A Comparison of The Performance of Genotype Mixtures and Pure Stands of Common Bean (*Phaseolus vulgaris* L.). M.S. Thesis, University of Wisconsin, Madison.
- BLISS, F.A. 1985. Relationships of genetic engineering to conventional genetic technology and plant breeding. (A.M. Altschul and H.L. Wilcic, eds.) "New Protein Foods - Seed Storage Proteins". Vol. 5:(In press).
- NORTON, G., BRESSANI, R. and BLISS, F.A. 1985. Biochemical and Nutritional Attributes of Grain Legumes (In press). In: Roberts and R. J. Summerfield (eds.) Grain Legume Crops (In press).

12.019 CRIS0074253
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY IN THE NORTH EAST

TIBBITTS T W; Horticulture; University of Wisconsin, Madison, **WISCONSIN** 53706.
 Proj. No.: WISO2364 Project Type: STATE
 Agency ID: SAES Period: 01 OCT 77 to 30 SEP 83

Objectives: Screen and select bean cultivars and lines with resistance to ozone injury. Establish the nature of genetic resistance to ozone injury in beans. Determine the physiological nature of resistance to ozone injury.

Approach: A number of bean lines and cultivars will be screened for susceptibility to ozone pollution in controlled environment fumigations. Two susceptible lines and two resistant lines with uniform response will be selected. Reciprocal crosses in all combinations will be made between the selected lines. The F(1) progeny will again be evaluated in controlled fumigations. Seed of the F(1) plants will be selfed to obtain F(2) progeny for additional fumigations to determine inheritance of the resistance and susceptibility. The physiological basis of resistance and susceptibility will be determined if possible. Seed of the parental

lines and progenies will be grown under field conditions in Wisconsin and Michigan to insure that evaluations made under controlled conditions are consistent with field response.

Progress: 77/10 to 83/09. Eighteen bean (*Phaseolus vulgaris* L.) cultivars were screened for sensitivity to ozone (O(3)) under controlled environmental conditions with exposures to 1.40 $\mu\text{l/l}$ for one hour. Two resistant cultivars, 'French's Horticultural' and 'Black Turtle Soup' had 25% fewer stomata per unit leaf area than two sensitive cultivars, 'Spurt' and 'Blue Lakes Stringless'. The resistant cultivars also exhibited partial stomatal closure in response to O(3) exposures, while the sensitive cultivars showed no closure. Resistance was found to be recessively inherited and regulated by more than one gene. The heritability of resistance to O(3) was estimated to be .83. Fumigation of peas (*Pisum sativum* L.) have demonstrated that O(3) concentrations as low as .04 $\mu\text{l/l}$ will increase the injury to pea plants from low levels of sulfur dioxide (SO(2)) and that SO(2) concentrations as low as .12 $\mu\text{l/l}$ will increase injury from low levels of O(3). Peas exhibited diurnal response to O(3) and SO(2), being more susceptible during midday than early or late. This increased injury at midday was closely related to stomata being open wider at midday. Stomatal responses were apparently not controlled by ABA, for ABA levels did not vary significantly at different times of the day. Pretreatment of pea plants to non-injurious low levels of O(3) induced a degree of pollution resistance, for injury was light in subsequent exposures with high levels of O(3) plus SO(2).

Publications: 77/10 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

12.020 CRIS0079894 DIURNAL FLUCTUATIONS IN SUSCEPTIBILITY OF CROP PLANTS TO AIR POLLUTANTS

TIBBITTS T W; Horticulture; University of Wisconsin, Madison, WISCONSIN 53706.
Proj. No.: WIS02499 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 83

Objectives: Determine the diurnal changes in susceptibility of plants to pollutants under natural conditions: With simultaneous ozone and sulfur dioxide exposure, with successive ozone and sulfur dioxide exposure, with plants under water stress.

Approach: Peas will be grown under carefully controlled conditions of light, temperature, humidity, and carbon dioxide. Plants will be exposed to ozone generated with ultraviolet lamps, and sulfur dioxide obtained from cylinders. Initially peas will be fumigated with combinations of ozone and sulfur dioxide individually and simultaneously at different times during the day. Secondly, peas will be exposed to low levels of ozone at different times during the day followed by fumigations with sulfur dioxide. Thirdly, peas will be subjected to varying levels of water stress by altering soil water and/or air moisture

conditions prior to or during ozone and sulfur dioxide fumigations at different times during the day. Measurements of stomatal response will be taken by use of diffusion porometers and silicone rubber impressions and measurements of water potential will be taken with a pressure bomb instrument. Injury will be determined by visual examination as well as by determination of chlorophyll levels. Data will be analyzed by "t" tests correlation analysis and analysis of variance to determine significant differences.

Progress: 83/01 to 83/12. Peas were found to have a diurnal response to O(3) and SO(2), being more susceptible during midday than early or late. This is attributed to stomata being open wider at midday. Stomatal responses were apparently not controlled by ABA, for ABA levels did not vary significantly at different times of the day. Peas pretreated with ozone at non-injurious concentrations prior to exposure with ozone-sulfur dioxide mixtures at injurious concentrations had less injury than those not pretreated. Peas grown at 77% relative humidity prior to exposure with ozone and/or sulfur dioxide were injured more than those grown at 36% relative humidity. Increased injury at the higher humidity was correlated with greater stomatal conductances. However, when peas were subjected to different humidity levels during pollutant exposures, injury was similar. Potatoes were found to be sensitive to SO(2) pollution during the dark period, but less sensitive than during the light period. Exposures of 1.75 ppm for 2 hrs during the dark period produced a level of injury similar to that produced by 1.25 ppm during the light period. Exposures were made toward the end of the dark period and in the middle of the light period during the time of maximum stomatal opening. The exposures in both the light and dark produced brown marginal interveinal necrotic areas that extended through the leaf. Dark exposures also caused brownish markings around the midvein that were restricted to the upper surfaces of the leaves.

Publications: 83/01 to 83/12

TIBBITTS, T.W. and KOBRIGER, J.M. 1982. Mode of action of air pollutants in injuring horticultural plants. *HortScience* 18(5):675-680.

KOBRIGER, J.M. and TIBBITTS, T.W. 1984. Effect of relative humidity during growth and during exposure on responses of peas to ozone and sulfur dioxide. Submitted to *J. Amer. Soc. Hort. Sci.*

KOBRIGER, J.M. 1982. Air pollution sensitivity of pea plants when simulating conditions around sulfur dioxide point sources. Ph.D. Thesis, University of Wisconsin, Madison, WI.

CM 13 ORNAMENTALS AND TURF

13.001 CRIS0003974 THE GENETICS, BREEDING, AND ECOLOGY OF TURFGRASS

GIBEAULT V A; Botany & Plant Sciences;
University of California, Riverside, CALIFORNIA
92521.

Proj. No.: CA-R*-BPS-1535 Project Type: STATE
Agency ID: SAES Period: 01 MAR 78 to 28 FEB 83

Objectives: Study genetics and breeding methods of turfgrasses; develop superior drought resistant strains with low nitrogen requirements; identify and introduce new germ plasm for turfgrass improvement; study growth and differentiation of vegetative and floral structures of grasses; study turfgrass responses to environmental factors including soil and air temperature, soil moisture, day length, nutrient levels, soil aeration, and air pollution.

Approach: Breeding studies will be conducted in field at South Coast Field Station, and in greenhouse at Riverside, using standard methods. Species relationships will be studied cytologically, morphologically, and biochemically. Plant responses will be studied in the greenhouses, controlled environment facilities, and laboratories at Riverside.

Progress: 84/01 to 84/12. Zoysia breeding studies culminated in the selection of UCR No. 1 for release as El Toro and the process was pursued in 1984 with scheduled release set for 1985. Management studies on El Toro showed the grass responded favorably to late fall fertilization and overseeding with annual, perennial, and intermediate ryegrass for winter color. Breeding between El Toro and other finer leaved zoysiagrasses was accomplished. The individual plants were space planted at UC Riverside for observation. The water conservation study was completed. Sprinkler irrigation was superior to subterranean irrigation for water conservation purposes. Also, warm season turfgrasses performed better than cool season turfgrasses when irrigated at less than optimum regimes.

Publications: 84/01 to 84/12

GIBEAULT, V.A., MEYER, J.L., STROHMAN, R., AUTIO, R., MURPHY, M., and MONSON, D. 1984. Irrigation of turfgrass below replacement of evapotranspiration as a means of water conservation. Final Report, Metropolitan Water District.

13.002* CRIS0074176 CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE-WATERS

WALKER J T; Plant Pathology; Georgia Agric
Expt Station, Experiment, GEORGIA 30212.
Proj. No.: GE001249 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 JAN 83

Objectives: Establishing an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate

matter deposited in various regions of the United States. Determining the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to the total atmospheric deposition in various states and regions in the United States. Organizing research in the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters; etc.

Approach: Establish a collector of the wet/dry type (Volchok and Graveson) at an approved collection site and ship samples on scheduled basis to a central analytical laboratory for analysis. Determine the contribution and importance of these depositions to the state and region in terms of agricultural productivity (Agronomic crops) and effects on vegetation (trees, shrubs, or turf) in the rural and urban environments, specifically in terms of diseases and contribution to minor element requirements.

Progress: 77/12 to 83/01. Using the protocol of the NADP guidelines, an Aerochem Metric Precipitation Collector (Model 201) was installed in the Georgia piedmont in October, 1978. A recording rain gauge, wind vane-anemometer, and particulate sampler was operated at the site. Ozone levels were monitored elsewhere. Precipitation samples were analyzed by the Central Analytical Laboratory. Particulates (TSP) were determined on a filter exposed for 24 h every 6 days. The effects of acidified water on a variety of plants under growth chamber, greenhouse, and field conditions were determined. The effect of aqueous solutions at different pHs on subsequent seed germination was studied. Over the 1979-81 period, the highest ionic constituent in rain was sulfate with an average of 2.6-3.5 mg/1/yr. followed by nitrate with 1.0 to 1.3 mg./1. The 3-yr. average for 9 ions in mg/1, was: Ca 0.24, Mg 0.13, K 0.18, Na 0.45, NH(4) 0.33, NO(3) 1.2, Cl 0.46, SO(4) 2.99, PO(4) 0.06. The lowest average pH occurred in the 2nd and 3rd calendar quarter, with values ranging from a low of 4.12 to high of 4.96. Average TSPs for 1979, 1980, and 1981, were 37.2, 38.7, and 46.7 mg./m³, respectively. Ozone averaged 3.6 pphm. Lead averaged .052 to .073 mg./m³ annually. Some plant species and cvs were injured by acidic mists at pH 1.8, but few plants were affected by pH 2.6 sprays. Grass seed germination was decreased by pH 2.6 solutions, but alfalfa, corn and cucumber were unaffected. Germination of some soybean cvs was reduced at pH 2.6.

Publications: 77/12 to 83/01
NO PUBLICATIONS REPORTED THIS PERIOD.

13.003* CRIS0089156
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
 ON AGRICULTURE, FORESTRY, SURFACE WATER, AND
 MATERIALS**

WALKER J T; Plant Pathology; Georgia Agric
 Expt Station, Experiment, **GEORGIA** 30212.
 Proj. No.: GE001341 Project Type: HATCH
 Agency IO: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish, the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings and other materials in machinery or structure.

Approach: The Georgia collection site has been operational since October, 1978, and will continue as part of the NAOP program. Data obtained is available to all interested scientists. Efforts research on agricultural and horticultural crops will encompass general growth responses including biomass and yield from simulated rain treatments and symptomatology. Influence of simulants on endemic pathogens of commercial crops will be determined in growth chambers and field plots. Cooperative studies with scientists in other departments and agencies will be initiated.

Progress: 84/01 to 84/12. The 1983 quarterly volume weighted average pH of rain falling at the Georgia NAOP/NTN site was 4.37, 4.71, 4.57 and 4.57. The six month average for 1984 is 4.50. The 1983 rainfall was 112.35 cm; for the first six months of 1984 it is 49.75 cm. Sulfate and nitrate remain the principle rainfall constituents, with deposition rates in 1984 comparable to those in 1983; six month sulfate rates were 878.6 and 823.3, respectively. Nitrate (NO₃) rates were 467.7 and 453.2. Total suspended particulates (ug TSP/M-3) averaged 23.7 for 1983, and 35.8 for nine months of 1984. Lead levels assayed on hi-vol filters remain low (0.03 mg/m³). Daily O₃ concentrations averaged 2.86 for May through October. A portable rain simulator, using Bete Simulated Rain Nozzles and PVC pipe, was constructed. Trials revealed that the 2.5 cm pipe with pumping system at 5 or 10 psi delivered 2.1 gals per minute to adequately wet soybean foliage. This deposition rate approximates 0.64 cm/h. To evaluate the system, Davis soybeans were planted on June 18 in a field previously fertilized with 2173 kg. of 5-10-15 per hectare. Lasso was applied after planting and the field irrigated on June 19 to enhance germination. Simulated rain (pH 3.5) was applied to soybeans in each of three 2.4mx2.4m plots at 2 rates, 208 or 416 liters, on four dates from August 21 to September 28. Plants in each plot were counted and bean yield determined at maturity. No visible injury was detected on soybean foliage.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

13.004* CRIS0066186
**CROP AND ORNAMENTAL PLANT TOLERANCE TO SULFUR
 DIOXIDE AND OZONE AIR POLLUTANT EXPOSURE**

BOOTH J A; Entomology & Plant Pathology; New Mexico State University, Las Cruces, **NEW MEXICO** 88003.
 Proj. No.: NM-1-3-42220 Project Type: STATE
 Agency IO: SAES Period: 01 JUL 82 to 30 JUN 84

Objectives: Complete studies now in progress re. effects of SO₂ on pecan nut quality. Determine differences in susceptibility to ozone SO₂, and mixtures of the two among commercial cultivars of alfalfa, chile pepper, and cotton. Identify and isolate pollution tolerant individuals through selections from large populations of alfalfa representing many cultivars.

Approach: Pecan nut quality alterations resulting from exposure to 3.0 ppm-hrs of SO₂ will be determined by measurement of nut weight, volume, density, meat wt., meat protein and liquid quantity. Treatments will be made biweekly throughout the 1982 season. Large numbers of plants of cultivars of alfalfa, cotton and chile pepper will be exposed to SO₂, ozone, and mixtures of the two gases in order to identify those which show tolerance to one or both of the gases. Vegetative propagation of tolerant lines will be used to isolate promising germ plasm for use in genetic improvement programs. The technique of convert sulfites to sulfate. Vegetative propagation will be used to isolate promising germ plasm for use in improvement programs.

Progress: 84/01 to 84/06. On December 20, 1983 the greenhouse housing the SO₂ treatment facility, and all of the isolated selections of alfalfa which showed some degree of tolerance to SO₂ exposure, were lost in a fire. In the subsequent months, especially considering the high cost of replacement of the facility, the decision was made to terminate this project and change the research direction. Existing data which was complete enough for publication was assembled, and at this point in time it appears that two manuscripts having to do with SO₂ effects on pecan nut retention and quality will be submitted for journal publication. The alfalfa SO₂ tolerance research had not progressed sufficiently for publishable data to be accumulated.

Publications: 84/01 to 84/06
 NO PUBLICATIONS REPORTED THIS PERIOD.

13.005 CRIS0084878
**FOLIAR NUTRITION OF HORTICULTURAL PLANTS FOR
 IMPROVED PRODUCTION & MAINTENANCE RUN-OFF &
 POLLUTION**

GORTZIG C F; GOOD G L; BOODLEY J W;
 Floriculture & Ornament Hort; Cornell
 University, Ithaca, **NEW YORK** 14853.

Proj. No.: NYC-141303 Project Type: STATE
Agency ID: SAES Period: 01 JUL 81 to 30 SEP 84

Objectives: Evaluate uptake, translocation, and utilization of foliar applied nutrients to satisfy nutritional needs, and improve production and maintenance efficiency of horticultural plants; to conserve energy and fertilizer; to reduce environmental contamination by nutrients; to examine the cuticle of horticultural plants as a basis of understanding the primary barrier to uptake of foliar applied substances; and to adapt research findings to commercial production and maintenance systems.

Approach: Genetically uniform plants will be grown in controlled environment facilities. Radioisotopes of important nutrient elements will be added to the foliage of these plants in a variety of environmental conditions. Electron microscopy studies will investigate the role of plant cuticle in foliar absorption. Commercially important horticultural plants will be grown with foliar nutrition to determine the commercial effectiveness of the system.

Progress: 83/01 to 83/12. Research activity of this project is completed and technical papers are being prepared by involved faculty and their graduate students.

Publications: 83/01 to 83/12

PAPAROZZI, E.T. 1983. Development and anatomical changes in leaves of yellow birch and red kidney bean exposed to simulated acid precipitation. *J. Amer. Soc. Hort. Sci.* 108(6).

KEEVER, G.J. and JACOBSEN, J.S. 1983. Response of Glycine max (L.) Merrill to simulated acid rain I environmental and morphological influences on the foliar leeching of the superscript 86 RG. *J. Field Crops Research*. Vol. 6, 241-250.

KEEVER, G.J. and JACOBSEN, J.S. 1983. Response of Glycine max (L.) Merrill to simulated acid rain II localization of foliar injury and growth response. *J. Field Crops Research*, Vol. 6, 251-259.

KEEVER, G.J. and JACOBSEN, J.S. 1983. Simulated Acid Rain Effects on Zinnia as Influenced by Available Nutrients. *J. Amer. Soc. Hort. Sci.* 108(1):80-83.

13.006* CRIS0043696
ULTRASTRUCTURAL STUDIES OF NURSERY CROPS, THEIR DISEASES AND INSECT PESTS

KRAUSE C R; Crop Systems Evaluation Res
Grasslnd, Soil & Water Res Lab; USDA
Agricultural Research Service, Delaware, OHIO
43015.

Proj. No.: 3606-20030-006-00D

Project Type: INHOUSE
Agency ID: ARS Period: 11 MAR 77 to 11 MAR 84

Objectives: Develop techniques to identify nursery crop cultivars. Develop accurate methods for specific diagnosis of air pollution-induced injury to nursery crops. Identify specific etiological disease agents

and pests of nursery crops and analyze host-parasite relationships.

Approach: Lab, Greenhouse and field grown nursery crops will be studied using scanning electron (SEM) and transmission electron microscopy (TEM) & energy dispersive x-ray analysis to distinguish unique surface features among crop cultivars, identify and describe morphological changes caused by exposure to ozone, nitrous oxides, sulfur dioxide, acid rain & salt, develop a procedure to identify the presence of selected disease and insect pests and/or their damages, elucidate Host-parasite relationship that shows promise for increasing our opportunity to improve disease control methods.

Progress: 83/01 to 83/12. A method for rapid transfer of scanning electron microscopic (SEM) Acer rubrum, red maple, that eliminates fixation or temperature artifacts was developed specifically for use in cultivar identification with SEM, a reliable and quick test to separate cultivars of the same species. Secondary morphological structures were found with SEM to enable sexing of Hylurgopinus rufipes, that native elm bark beetle vector of Dutch elm disease (DED). Improved identification methods could lead to a better understanding of bark beetle behavior and the DED cycle. SEM and energy dispersive X-ray analysis were used to detect air pollution injury to red maples grown in areas of high ambient levels. Particles containing Pb, Fe, S, Cl, Zn, Ti, etc., were associated with irregular wax and lesions. Needle surface of SO(2)-tolerant and SO(2)-sensitive clones of Pinus strobus were examined with SEM. Epistomal wax formed a continuous covering over stomata of tolerant clones, but was split longitudinally over the stomata of sensitive clones.

Publications: 83/01 to 83/12

KRAUSE, C.R. 1983. A sample transfer procedure for SEM. *J. Environ. Hort.* (2):36-38.

KRAUSE, C.R. and FINGERHUT, B.A. 1983. Sexing Hylurgopinus rufipes with SEM. *Proc. Entomo. Soc. Wash.* 85:748-752.

KRAUSE, C.R. 1983. Detection of air pollution injury to red maples leaves with EDX. SEM-83/III:1493-1497.

13.007* CRIS0076369
SOIL FERTILITY, MANAGEMENT, AND PLANT NUTRITION FOR FORAGE AND HORTICULTURAL CROP PRODUCTION IN EAST TEXAS

HABY V A; Research & Extension Center; Texas
A&M University, Overton, TEXAS 75684.

Proj. No.: TEX06320 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 83 to 30 JUN 88

Objectives: Determine the influence of varying levels of soil acidity on the availability of soil and applied fertilizer nutrients for roses and warm and cool season grasses and legumes. Evaluate the efficiency of applied N and that fixed by leguminous plants for small grains and warm season grass production. Evaluate the influence of K fertilizers on

disease reduction in small grains and Coastal bermudagrass. Determine the soil fertility and fertilizer requirements of blueberries and peaches under East Texas conditions. Determine the effect of acid rain on East Texas soils and crops. Relate crop responses from various plant nutrient applications to the soil test level of those nutrients in order to improve the predictability of the soil test for fertilizer needs.

Approach: Field studies on bench mark soils of East Texas will be used to evaluate the responses of soils and crops to fertilizer nutrients and limestone. Greenhouse research will support the field studies. Soil and plant analyses in the laboratory will help evaluate field and greenhouse experiment responses. Data will be evaluated by appropriate statistical analyses.

Progress: 84/01 to 84/12. Ryegrass yield responses to limestone rates of 0, 672, and 3810 kg/ha were 3119, 5063, and 6020 kg/ha, respectively. Yields increased from 4120 to 5629 kg/ha as P rate increased from 0 to 240 kg/ha, respectively. Winter wheat grain yield increased from 1463 to 4016 kg/ha with N rate increments from 0 to 224 kg/ha, respectively, but yield differences due to the N sources ammonium nitrate, urea, and urea phosphate were negligible. Prior year growth of subterranean clover contributed the equivalent of 70 kg N/ha to the wheat. Winter wheat grain yields were similar for KCl and K(2)SO(4) potassium sources. Yield response to K rate increases was not statistically significant. A versatile, three-point hitch, tractor-mounted applicator was designed and constructed to dispense fluid fertilizers from containers pressurized by a tractor-mounted and powered pressure system. This applicator is used to evaluate dribble band spacings, methods of application, rates, and combinations of fluid fertilizers applied to Coastal bermudagrass. A severe summer drouth restricted growth but grass yield from the three harvests was significantly increased from 11,500 to 15,928 kg/ha as N rate increased from 45 to 135 kg/ha at site one, and from 8064 to 10,080 at site two which is a less responsive soil. Banded urea-ammonium nitrate at spacings of 18, 36, 53, and 71 cm between bands, and method of application had no significant effect on grass yield. Nitrogen source comparisons yielded mixed results between both sites.

Publications: 84/01 to 84/12

- NELSON, L.R., HABY, V.A., BATEMAN, C. and KREJSA B. 1984. Accumulation of Al, Ca, Mg, Mn, K and P in annual ryegrass due to soil flooding. American Society of Agronomy Abstracts.
- BRANDT, J.E., HONS, F.M. and HABY, V.A. 1984. The effect of nitrogen management on the yield and nitrogen uptake efficiency of soft red winter wheat. American Society of Agronomy abstracts.
- HABY, V.A., DAVIS, J.V. and SMITH, K.L. 1984. A versatile fluid fertilizer applicator for field research. American Society of Agronomy Abstracts.

14.001* CRIS0089797
GENETIC EFFECTS OF FLUORIDE ON SELECTED PLANT SPECIES

SAPRA V T; SHARMA G C; SHUFORD J W; Natural Resources & Env Studis; Alabama Agric and Mech Coll, Normal, ALABAMA 35762.
 Proj. No.: ALAX-3-40-14-3150 Project Type: STATE
 Agency ID: OCI Period: 10 SEP 80 to 10 AUG 84

Objectives: To study the effect of different concentrations of fluoride on mitotic and meiotic cell division in corn and tomatoes, and study the mutagenic effects and reproduction incompatibilities induced by toxic levels of fluoride.

Approach: Two plant species, corn and tomatoes (sensitive to hydrogen fluoride) were studied under controlled environmental growth chambers. Plants were exposed to both air and soil application of fluoride at different concentration. Genetic effects of fluoride was studied in first generation exposed to air and soil borne fluoride. Mitotic and meiotic cell division was studied. Mutagenic effects was judged by observing morphological characteristics in fluoride treated plants. The estimation of fluoride in air was measured by ion specific electrodes.

Progress: 84/01 to 84/08. In 1983-84, a study on the effect of fluoride on tomato plant was undertaken in a fumigated growth chamber on two tomato varieties (Fluorodale and Campbell 37). Three levels of HF rates (0, 16, 30 g/ , three durations (4, 8, 12 days) were used on three-week-old tomato seedlings. The results showed foliar fluoride injury developed on tomato plants receiving all of the HF treatment combinations, except plant receiving four days exposure at 16 mu g/m showed no injury. Post-fumigation analyses of tomato plants and fruit for fluoride showed that increase in HF rate from 16 mu g/m to 30 mu g/m significantly fluoride content in 4-week plant, 14-week plant and tomato fruit. According to our previous results on corn, HF gas can induce significant chromosomal aberrations in mitosis and meiosis, but in the present study tomato reacted differently. Chromosomal abnormality was found at 16 mu g/m of 4-day treatment in variety Florodale.

Publications: 84/01 to 84/08

- WANG, J.K. 1983. Mutagenic effects of gaseous hydrogen fluoride on maize. M.S. Thesis. Alabama A&M University, Normal, AL.
 WANG, J.K., SAPRA, V.T. and SHARMA, G.C. 1983. Mutagenic effects of gaseous hydrogen fluoride on maize. Int. Congress of Genetics, New Delhi, India. Part I. p. 344.

14.002* CRIS0084091
EFFECTS OF SO(2) AND OZONE ON GROWTH, PRODUCTIVITY, PHYSIOLOGY AND BIOCHEMISTRY

LAUHLI A W; TIMM H; YANG S F; Inter Departmental; University of California, Davis, CALIFORNIA 95616.
 Proj. No.: CA-D*-XXX-4108-H Project Type: HATCH
 Agency ID: CSRS Period: 12 MAY 81 to 30 SEP 86

Objectives: To determine the effects of SO(2) and ozone on several varieties of field crops and vegetable differing in resistance to these air pollutants, in terms of growth, productivity, mineral nutrient uptake and osmotic relations of the plants, biochemical studies on lipid metabolism and ethylene production as related to SO(2) sensitivity, and to investigate the interactions between SO(2) and ozone stress and salinity.

Approach: Exposure to the air pollutants will be done in an environment-controlled chamber. SO(2) and ozone will be applied singly or in combination, and also in combination with salt stress. Growth will be measured as germination, emergence, root growth, and by protein analysis. Effects on nutrition will be assessed by ion transport experiments using radiotracers and measurement of inorganic and organic solutes. Stomatal apertures will be monitored with a diffusion porometer. The biochemistry of SO(2) injury will be determined by measuring production of ethane and ethylene and by following oxidation of SO(2) by sulfite measuring production of ethane and ethylene and by following oxidation of SO(2) by sulfite oxidase.

Progress: 84/01 to 84/12. Low level effects of SO(2) on tomato, alfalfa and cucurbits were studied. Germination of seed and pollen was unaffected, but root growth of tomato seedlings was extremely retarded by SO(2). (-) Cucurbit roots were less SO(2) sensitive. Root growth appears SO(2) sensitive because of HSO(3) formation in the medium. Pollen tube growth of all tested species was inhibited by SO(2). Effects of low level ozone pollution on growth and yield of beans were studied in the field using open-top field chambers. Two chamber designs were tested. Two-blower chambers were more effective in maintaining temperatures similar to ambient in the presence of plants than were one-blower chambers. Photosynthetically active radiation (PAR) was reduced by 20% within the chambers compared to ambient. Ozone variability in the chambers was only slight. Data on physiological parameters, growth and yield of beans under low-level ozone fumigation are being analysed. Initial results showed that "Blue Lake" bean growth was inhibited by 5 hr. daily fumigations with 0.06-0.08 mu O(3). A comprehensive final report for Air Resources Board is in preparation.

Publications: 84/01 to 84/12

- TIMM, H. and BARNES, K. 1984. Pollen germination and tube growth responses to low level SO(2) exposure. Hort Science 19(3)72.

14.003 CRIS0097371
A FIELD OF STUDY OF DRY DEPOSITION OF AIRBORNE MATERIALS TO SOYBEAN AND CORN

DOLSKE D A; Atmospheric Chemistry Section; University of Illinois, Champaign, ILLINOIS 61820.
 Proj. No.: ILLR-8501666 Project Type: CRG0
 Agency ID: CRG0 Period: 01 SEP 85 to 31 AUG 86

Objectives: PROJECT 8501666. The primary objective of this project is to routinely measure the dry deposition of sulfur and nitrogen - containing air pollutants to soybeans and corn. This information will be used to examine the interaction of dry- and wet-deposited materials on the plant surface.

Approach: Foliar surface sampling techniques are developed to provide a method for precisely and routinely determining the amount of dry deposition received by crop systems during the growing season. The methods will be used in a coordinated program of surface sampling, throughfall collection and event-basis precipitation sampling--in both ambient rain and using simulated rain at pH's below and above ambient values.

14.004* CRIS0082896
SULFUR DIOXIDE AND ACID RAIN: COMPARATIVE UPTAKE AND NEUTRALIZATION OF SULFUR POLLUTION BY PLANTS

CRAKER L E; Plant & Soil Sciences; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00499 Project Type: HATCH
 Agency ID: CSRS Period: 01 NOV 80 to 30 SEP 86

Objectives: Examine and quantify the effectiveness of plants in the uptake and neutralization of sulfur pollution. compare the two major forms of atmospheric sulfur pollution (SO₂) and acidic rain) for their relative hazard to the plants.

Approach: The individual and collective response(s) of plants will be examined following exposure to sulfur pollution as SO₂ or sulfuric acid rain. Initial studies are selectively short term and designed to determine the contribution of plants to the absorption and neutralization of SO₂ and acid rain plus evaluate the acute injury to plants caused by SO₂ and acid rain. Longer term studies will be used to investigate the cumulative response of model plant populations to SO₂ and to simulated acid rain.

Progress: 83/10 to 84/09. The susceptibility of plants to sulfur containing acid rain, sulfur dioxide, and combinations of acid rain and sulfur dioxide have been evaluated. Simulated pollution episodes have been studied with corn, Zea mays. Uptake and absorption of sulfur into plant tissue is greatest under high sulfur dioxide concentrations and low pH acid rains. More sulfur is absorbed from sulfur dioxide than from sulfur containing acid rain when both have equivalent amounts of sulfur. Sulfur containing acid rain may inhibit pollenization and fertilization of corn in the field. An evaluation of acid neutralizing powers of crop leaf tissue demonstrated significant differences among plants. Red Kidney beans and wheat leaves had the greatest buffering capacity.

Publications: 83/10 to 84/09
 CRAKER, L.E. and BERNSTEIN, D. 1984. Buffering of acid rain by leaf tissue of selected crop plants. Env. Pollut. (in press).
 SIMON, J.E. 1984. Comparative uptake of sulfur in sulfur dioxide and acid rain by corn. Ph.D. Thesis, Univ. of Massachusetts.

14.005 CRIS0093291
SUSCEPTIBILITY OF THE REPRODUCTIVE PROCESS IN CORN TO ACID PRECIPITATION

CRAKER L E; HERBERT S J; Plant & Soil Sciences; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00579 Project Type: SPECIAL GRANT
 Agency ID: CSRS Period: 01 JUN 84 to 31 MAY 86

Objectives: To evaluate the sensitivity of the reproductive process in corn to acid precipitation as measured by the effect of ambient and simulated acid rain on pollen germination and growth in situ, and corn yield. To quantify the vulnerability of corn pollen to acid precipitation.

Approach: Three commercially important corn varieties will be evaluated for susceptibility to acid precipitation in the ambient environment through the production of viable pollen and the germination and growth of pollen on silks. In addition, the susceptibility of pollen to simulated acid rains differing in pH and inorganic constituents but based on the actual chemistry of precipitation in the eastern U.S. will be tested.

14.006* CRIS0097557
THE EFFECTS OF ATMOSPHERIC POLLUTANTS ON THE REPRODUCTION OF AGRICULTURAL CROPS

DUBAY D; STUCKY J; NEAGLE A; Botany; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
 Proj. No.: NC09340 Project Type: CRGO
 Agency ID: CRGO Period: 01 SEP 85 to 30 SEP 87

Objectives: Proj 8501684. Determine the direct effects of simulated acid reproduction of corn, soybean, wheat, cotton, snap bean, and tomato, determine the influence of chronic O₃ exposure on the effects of acid rain on cotton and soybean reproduction. Determine the effects of acid rain on the viability and fitness of seeds produced by treated flowers.

Approach: Flowers are exposed once to simulated rain of different acidities. Cotton and soybean are grown before and after rain treatment in chambers with charcoal-filtered air or air with added O₃. Treated flowers are scored for seed production, and seeds are tested for viability and fitness.

14.007 CRIS0046127
**LOSS OF CROP PRODUCTION BY OZONE, SULFUR
 DIOXIDE, NITROGEN DIOXIDE AND OTHER MIXTURES**

MIKSCH J P; HECK W W; Botany; N Carolina
 State University, Raleigh, **NORTH CAROLINA**
 27650.

Proj. No.: 7005-20790-008-00S

Project Type: COOPERATIVE AGREE.

Agency ID: ARS Period: 01 APR 80 to 30 SEP 83

Objectives: Develop a National crop loss assessment program to determine the loss of crop production by ozone, sulfur dioxide, nitrogen dioxide and their mixtures.

Approach: Determine dose-response curves for selected important economic crops (i.e. soybean, corn, wheat, oats, forages) from exposure to ambient air pollutants under field conditions. Experimental designs will utilize open-top field chambers over small field plots. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at 2 weeks from seeding. Plants will be exposed to background ozone, ambient ozone and three or four higher ozone increments for 7 hrs/day over the summer. Ozone increases will be set amounts over ambient so normal daily fluctuations will be observed. Similar designs will be used for sulfur dioxide, nitrogen dioxide and gas mixtures.

Progress: 81/01 to 81/12. Peanut ('NC-6'), soybean ('Davis', 2 designs) and cotton ('Stoneville 213') were exposed to 4 to 5 different chronic doses of ozone (O(3)) in open-top field chambers from seedling to harvest. Data were analyzed using linear regression and several three-parameter models were tested; the Weibull function was considered the best. Estimates of yield reductions at ambient concentrations of O(3) (0.05 to 0.06 ppm for a 7-hr/day seasonal mean) were: peanut - 12 to 19%, soybean - 5 to 24% and cotton - 10 to 16%. A zonal air pollution system was developed, tested and used in the exposure of field grown peanuts. The first soybean study also used four chronic doses of sulfur dioxide (S(2)); no interactions were found and, except at the highest concentration used, no S(2) effects were reported. In the second soybean study, O(3) additions were constant or proportional and the amount of solar radiation interrupted by the canopy was used as a measure of growth; yield was not affected by the means of adding O(3); radiation interpreted over the growing season correlated well with plant growth dynamics. The cotton study also used four chronic doses of S(2) and had a single replication where frusta were added to the chambers to control ingress of ambient pollutants; no interactions were found and only the highest S(2) concentration caused a yield reduction in cotton; the addition of the frusta did not affect cotton sensitivity to O(3).

Publications: 81/01 to 81/12

HECK, W.W., TAYLOR, O.C., AOAMS, R., BINGHAM, G., MILLER, J., PRESTON, E. and WEINSTEIN, L. 1982. Assessment of Crop Loss From Ozone. J. Air Pollut. Contr. Assoc.

32:353-361.

HEAGLE, A.S., LETCHWORTH, M.B. and MITCHELL, C. 1983. Injury and yield responses of peanuts to chronic doses of ozone in open-top chambers. Phytopathology 73:551-555.

HEAGLE, A.S., HECK, W.W., RAWLINGS, J.O. and PHILBECK, R.B. 1983. Effects of chronic doses of ozone and sulfur dioxide on injury and yield of soybeans in open-top field chambers. Crop Sci. 23:1984-1191.

HECK, W.W., AOAMS, R.M., CURE, W.W., HEAGLE, A.S., HEGGESTAO, H.E., KOHUT, R.J., KRESS, L.W., RAWLINGS, J.O. and TAYLOR, O.C. 1983. A reassessment of crop loss from ozone. Environ. Sci. and Tech. 17:573-580A.

HECK, W.W., CURE, W.W., RAWLINGS, J.O., ZARAGOZA, L.J., HEAGLE, A.S., HEGGESTAO, H.E., KOHUT, R.J., KRESS, L.W. and TEMPLE, P.J. 1984. Assessing impacts of ozone on agricultural crops: I. Overview. JAPCA 34:729-735

14.008 CRIS0047266
**FIELD STUDIES OF PLANT RESPONSES TO ELEVATED
 CARBON DIOXIDE LEVELS**

THOMAS J F; ROGERS H H; Botany; N Carolina
 State University, Raleigh, **NORTH CAROLINA**
 27650.

Proj. No.: 7009-20790-009-00S

Project Type: COOPERATIVE AGREE.

Agency ID: ARS Period: 22 JUL 81 to 30 SEP 84

Objectives: Establish dose-response relationships between various elevated CO(2) levels and crop production as well as some key crop processes.

Approach: The general approach for this work will use a plant exposure system (with open top chambers) for the generation of large-scale CO(2) test atmospheres in the field. Selected economically important crops will be exposed within the system over the growing season. The system is both cost effective and mechanically reliable over long time periods. The system further provides an environment as identical to field conditions as possible, given the above constraints. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at seeding. Plants will be exposed to ambient CO(2) and variable other set concentrations throughout their life cycle.

Progress: 81/01 to 81/12. A field program was designed and tested in 1980 to expose crop plants under field conditions to elevated levels of CO(2) (above ambient). Soybean was used as the primary test species but sweet potato was included in the last year of the study. Plants were grown in pots for the first two years and in the soil (ground) under normal field practices the last two years. Open-top field Chambers, developed to study ambient pollution effects on crop growth, were used to control the CO(2) concentrations around the test plants. Conical tops (frusta) were used to reduce ingress of outside air and make better utilization of CO(2) gas. Plants were grown from seedlings (1 or 2 weeks) to maturity under

the different CO₂ regimes. Soil moisture stress was a variable several years. Studies included effects on water relations (water use efficiency), photosynthesis and movement of photosynthate, stomatal function, growth analysis, anatomical changes, growth and yield of mature plants. Elevated CO₂ during soybean growth generally resulted in: increased node number, increased water use efficiency, decrease of whole plant N to dry matter ratio in pot-grown plants, increase in root nodule mass, extra carbon fixed is partitioned to starch, increased plant weight more in water stressed than non-stressed plants, increased seed dry weight.

Publications: 81/01 to 81/12

- ROGERS, H.H., BINGHAM, G.E., THOMAS, J.F., SMITH, J.M., ISRAEL, D.W. and SURANO, K.A. 1982. Effects of long term concentration on field grown crops and trees. In: "Global Dynamics of Biospheric Carbon." pp. 9-45. Department of Energy, O19.
- DAVIS, J.M., RIORDAN, A.J. and LAWSON, R.E. 1983. A wind tunnel study of the flow field within and around open-top chambers used for air pollution studies. Bound. Layer Meteorol. 25:193-214.
- ROGERS, H.H., HECK, W.W., and HEAGLE, A.S. 1983. A field technique for the study of plant responses to elevated carbon dioxide concentrations. J. Air Pollut. Contr. Assoc. 33:42-44.
- ROGERS, H.H., BINGHAM, G.E., CURE, J.D., SMITH, J.M. and SURANO, K.A. 1983. Responses of selected plant species to elevated CO₂ in the field. J. Environ. Qual. 12:569-574.
- ROGERS, H.H., THOMAS, J.F. and BINGHAM, G.E. 1983. Responses of agronomic and forest species to elevated atmospheric carbon dioxide. Science 220:428-429.

14.009 CRIS0047610 RESPONSE OF PLANTS TO MIXTURES OF SELECTED ATMOSPHERIC CONTAMINANTS

HUANG J; REINERT R A; Plant Pathology; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
Proj. No.: 7013-20790-012-00S
Project Type: COOPERATIVE AGREE.
Agency ID: ARS Period: 21 APR 82 to 30 SEP 84

Objectives: Develop a greenhouse exposure system for studying the effects of up to three gaseous contaminants in various combinations. Determine short and long-term effects of gas mixtures on plant growth and productivity in both greenhouse and field exposures.

Approach: Design a multiple chamber greenhouse exposure system for the study of pollutant mixtures. Determine ratios and combinations of gaseous pollutants that occur in ambient air. Design experiments to include the above mixtures and their multiple so as to develop response surfaces for various gas mixtures. Determine plant response to these mixtures. Plan selected studies to help determine the mechanism of plant response and resistance.

Progress: 82/04 to 84/09. Systems were developed for studying the effect of gaseous contaminants ozone (O₃), sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) on crop plants. These systems included: 1) a charcoal filtered air (CF) and non-filtered air (NF) greenhouse section, 2) 20 plant exposure chambers 4 ft dia. by 4 1/2 ft tall placed in a CF 30 x 40 greenhouse section and facilitated with a pollutant dispensing and monitoring system, and 3) 12 rotating tables place in a 20 x 40 ft CF greenhouse section for exposing plants to simulated rain at different pH levels. Numerous plant species were grown in both CF and NF greenhouse air and developed O₃ injury in the NF air but not in the CF air. Soybean, cv. Bragg, were grown and exposed to NO₂ (0.0, 0.1, or 0.2 ppm) and SO₂ (0.0, 0.2, and 0.3 ppm) singly and in combination. Plants were harvested after either 5 or 15 exposures. Leaf discs from trifoliate leaves were sampled for ribulose biphosphate carboxylase (RuBPC) activity and protein concentration. After 15 exposures to SO₂ RuBPC enzyme activity increased and then decreased in a curvilinear manner in the younger leaf tissue and decreased in a linear manner in older leaf tissue. Stem and leaf dry weight was significantly reduced by SO₂ while root weight was significantly reduced by mixtures of SO₂ and NO₂. Experiments were initiated to study the uptake and metabolism of CO₂ in soybean leaves following exposure to SO₂ and NO₂, alone and in combination.

Publications: 82/04 to 84/09

- KLARER, C.I., REINERT, R.A. and HUANG, J.S. 1984. Effects of sulfur dioxide and nitrogen dioxide on vegetative growth of soybeans. Phytopathology 74:1104-1106.
- KLARER, C.I., HUANG, J.S. and REINERT, R.A. 1984. Changes in ribulose biphosphate carboxylase activity, protein concentration and vegetative growth of soybeans over time in response to sulfur dioxide and nitrogen dioxide.
- REINERT, R.A. 1984. Plant response to air pollutant mixtures. Ann. Rev. Phytopath. 22:421-422.
- KLARER, C.I. 1983. Effects of sulfur dioxide and nitrogen dioxide singly and in combination over time, on ribulose biphosphate carboxylase activity in vegetative growth of soybean. MS. degree, Department of Plant Pathology.

14.010 CRIS0092660 INTERACTIONS BETWEEN ACIDIC PRECIPITATION & ARTHROPODS: THROUGHFALL EFFECT, SOIL CHEMISTRY & CROPS

STINNER B R; STINNER D H; Entomology; Ohio Agric Res and Devlp Center, Wooster, **OHIO** 44691.
Proj. No.: OH000360-SS Project Type: STATE
Agency ID: SAES Period: 01 DEC 83 to 31 MAR 85

Objectives: The objectives of the research are to determine the effects of simulated acidic precipitation on foliage feeding insects and consumption levels on corn, soybeans and alfalfa, quantify the interactive effects of

insect consumption of crop foliage and acid precipitation on throughfall and soil chemistry, determine the influence of acid precipitation on soil arthropod population density and trophic structure, quantify the effects of acidic precipitation on the decomposition of crop residues, and relate the above interactions to crop nutrient uptake and yield.

Approach: These objectives will be addressed through a series of greenhouse experiments and field documentation. The resultant data will provide information on a potentially major interactive effects of acid precipitation in agroecosystems. In particular, we will be able to determine subsidy/stress trade offs on crops due to the interactive effects of acid precipitation and foliage and soil arthropods.

Progress: 84/01 to 84/12. A summary of results of our greenhouse experiments in which we have investigated responses of 4th, 5th, and 6th black cutworm instars on 1 and 2 leaf corn plants to simulated pH 2.8, 4.2 and 5.6 precipitation are as follows. We observed some specific life stage sensitivities in total herbivory, particularly the 6th instar. However, the results depended on which stage of corn the larvae were initially placed. Sixth instars on 1 leaf corn cut significantly more plants in the 2.8 treatments than in the 5.6 treatments. In contrast, 6th instars on 2 leaf corn cut significantly fewer plants in the 2.8 treatment than in the 5.6 treatments. The latter observation corresponded to significantly lower pupal weights in the 2.8 than in the 5.6 treatments for 6th instars on 2 leaf corn. Lumping data across instars by leaf stage, we observe that less cutting occurred overall on the 2 leaf corn than the one leaf corn, and that statistical differences between treatments disappear. This is even more dramatic if the data are lumped across instars and leaf stages, which probably most closely reflects a real corn field situation.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

14.011* CRIS0084372
SULFUR AND NITROGEN COMPONENTS OF PRECIPITATION AND EFFECTS ON SOIL FERTILITY AND PLANT NUTRITION

CRADDOCK G R; PITNER J B; Agronomy & Soils; Clemson University, Clemson, SOUTH CAROLINA 29631.

Proj. No.: SC00501 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 81 to 31 DEC 85

Objectives: Determine the contribution of sulfur in precipitation and partifur in soils. Determine the response of corn (Zea mays) to different rates of sulfur applied at varying rates of nitrogen to a Typic Paleudult. Determine the contribution of nitrogen (NH(4) +NO(3)) and sulfates in atmospheric deposition to plant nutrition and quantify their potential effects on fertilizer sulfur and nitrogen needs for corn.

Approach: Corn fields representing the principle South Carolina soil series will be selected and the sulfur content of soil and corn leaf monitored for six years. Concurrently on the same fields, sulfur in the ambient atmosphere and that in precipitation will be monitored monthly to ascertain the trends in contribution of atmospheric sulfur to the soil and plant supply. A long term field experiment will be initiated with corn at the Pee Dee Experiment Station. The basic fertilizer will contain sulfur-free materials and will comprise one treatment - the control. Other treatments will consist of side-dress applications of gypsum to supply 9, 18, and 36 kg/ha of sulfur respectively at two rates of nitrogen. Concurrently chemical components of acid precipitation will be monitored weekly at the Pee Dee Experiment Station and at Clemson University.

Progress: 84/01 to 84/12. Final year of a 4-yr field study for response of corn (zea mays) to added S will be completed and summarized in 1985. Using treatments of 0, 9, 18, and 36 kg/ha of added S on an Arenic Palendult resulted in a significant yield (P = 0.05) of 10% only for added S for the 1981 yr (1styr). Treatments receiving no S have ranged from 4,660 kg/ha to 11,200 kg/ha. Rainfall amount and distribution have greatly affected yields. Sampling for rainfall of S content will not be continued on a monthly routine basis during 1985 for the 16 sites throughout the state since the S. C. Dept. of Health and Environmental Control is no longer a cooperator. Sampling will continue at Clemson and tentative plans are to continue sampling at Florence and the Simpson Station. Total S content of rainfall varies slightly from year to year and is closely related to amount of rainfall.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

14.012* CRIS0088965
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

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Proj. No.: SC01034 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America; assess the effects of atmospheric deposition on productivity of agricultural crops, forest trees, rangelands, wetlands and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery and structure.

Approach: Major attention will be given to the collection, quantitative characterization, and chemical analysis of the water soluble and water insoluble substances contained in precipitation, airborne gases, and both fine aerosol and coarse particulate matter. The chemical substances of special interest include nutrient cations and anions, especially H⁺, NH₄⁺, SO₄²⁻ from April to August. During the month of July alone, 36.4% of the H⁺, 28.9% of the SO₄²⁻, and 24.2% of the NO₃⁻ was collected in 21.3% of the annual precipitation. The pH values were consistently higher in the months of September to January. These findings indicate that the amount of acid deposited in the past year would require addition of only 32 kg/ha of CaCO₃ for neutralization in farmlands of this region. At the same time, 6.9 kg/ha of N and 11.1 kg/ha of S were added, mostly during the growing season. While acid deposition may effect the chemistry of unmanaged soils over time, it remains clear that it should have little negative influence on soils of well managed farmland.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

14.013 CRIS0085227
**MODE OF ACTION OF SELECTED HERBICIDES AND
HERBICIDE ANTIDOTES**

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24061.
Proj. No.: VA-0612431 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Study the mode of action of selected herbicides and herbicide antidotes at cellular and subcellular levels to facilitate comprehension of aberrations in physiological functions of selected crop or weed plant species exposed to these chemicals. Study the phytotoxicity of the major metabolites of selected herbicides to determine whether metabolic modification of the parent herbicide molecules by higher plants leads to reduced or increased herbicidal activity.

Approach: Time-course and concentration studies including periods of 30, 60 and 120 min and concentrations of 0, 0.1, 1, 10, and 100 (μM) will be used to examine the effects of these chemicals on photosynthesis, protein, RNA, and lipid synthesis of enzymatically isolated leaf cells or protoplasts of selected crop or weed species. The cells or protoplasts will be incubated with radioactive substrates specific for each metabolic process to be studied. Analyses will include extraction, spectrophotometry and scintillation detection procedures. Interaction studies examining the effects of antioxidants and of the air pollutant oxone (O₃) on the activity of selected herbicides in the presence or absence of specific herbicide antidotes will also be examined.

Progress: 84/01 to 85/09. Studies with safened and unsafened corn showed that in the presence of the safener R-25788

(N,N-diallyl-2,2-dichloroacetamide) the thiocarbamate herbicide EPTC interacted synergistically with the air pollutant ozone and the antioxidants piperonyl butoxide and propyl gallate. Because the antioxidants piperonyl butoxide and propyl gallate act as inhibitors of mixed-function oxidases, it was concluded that R-25788 may protect grass crops against injury from thiocarbamate herbicides by stimulating the metabolic degradation of these herbicides in the protected plants. Naphthalic anhydride (NA) was the most effective of four antidotes tested as safeners for protecting corn against injury from the herbicide isouron. Cyometrinil, CGA-93194 alpha-(1,3-dioxolan-2-yl-methoxy-imino)-benzeneacetoneitrile, and R-25788 were ineffective as protectants of corn against this herbicide. NA and seven of its structural analogues applied as seed dressings of 0.5 and 1.0% by seed weight offered satisfactory protection to 'XL72AA' corn hybrid against injury from the herbicide EPTC. These analogues included the compounds: acenaphthenequinone, 4-amino-1,8-naphthalic anhydride, 1,4,5,8-naphthalenetetracarboxylic dianhydride, 1,8-naphthalimide, 4-chloro-1,8-naphthalic anhydride, diphenic anhydride and phthalic anhydride. The same antidotes antagonized significantly the EPTC activity on 'XL67' corn hybrid but the protection offered was partial and agronomically important.

Publications: 84/01 to 85/09

HATZIOS, K. K., 1983, Interactions of the herbicides EPTC and EPTC plus R-25788 with ozone and antioxidants in corn, J. Agric. Food Chem. 31:1187-1191.

HENRY, W. T. and HATZIOS, K. K., 1985, Interactions between the herbicide isouron and selected antidotes on two corn hybrids, Cereal Res. Comm. 13:000-000(In press).

HATZIOS, K. K. and ZAMA, P., 1985, Physiological interactions between the herbicide EPTC and selected analogues of the antidote naphthalic anhydride on two hybrids of corn, Pestic. Sci. 16:000-000 (In press)

CM 16 RICE

16.001

CRIS0081095

THE ECONOMICS OF RICE STRAW DISPOSAL IN THE SACRAMENTO VALLEY

GARDNER B D; Agri Economics; University of
California, Davis, CALIFORNIA 95616.

Proj. No.: CA-D*-AEC-3935-H Project Type: HATCH
Agency ID: CSRS Period: 05 MAR 80 to 31 DEC 84

Objectives: To quantitatively evaluate the effected economic impacts on rice producers and on the rice-related agricultural economy of alternative strategies for rice-straw management in the Sacramento Valley Air Basin (SVAB). Qualitatively identify and discuss the probable impacts on the public health and welfare of residents of the SVAB resulting from decreased emissions as alternative residue management strategies are substituted for open-field burning. Identify and discuss the economic impacts on the consumers of rice (both foreign and domestic) which could be effected with the implementation of burning substitutes.

Approach: Optimization techniques will be utilized to evaluate impacts on rice producers and conventional benefit-cost analysis will be employed to estimate impacts on consumers of rice and residents of the air basin.

Progress: 80/03 to 84/12. The overall objective of this research was to estimate the economic impact on the Sacramento Valley rice industry and surrounding economy of reduced reliance on open-field burning of rice straw. With the use of a computerized data base, Sacramento Valley soil types were classified into soil groups which vary by texture, drainage, and land use patterns. These soil groups were then ranked according to size and crop diversification and budgets were prepared for each class showing costs and benefits of producing various crops. A linear programming model was utilized to optimally allocate land to rice and other crops under various scenarios reflecting institutional controls on disposal of rice straw. Data giving permission for agricultural burning by the Air Resources Board were analysed to determine how restrictive and costly the burning policy has been and whether or not changes are needed.

Publications: 80/03 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

17.001 CRIS0074252
**REDUCING THE INFLUENCE OF AIR POLLUTION ON
 PLANT PRODUCTIVITY IN THE NORTHEAST**

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 Agronomy; University of Maryland, College Park,
 MARYLAND 20742.
 Proj. No.: MD-B-127 Project Type: HATCH
 Agency IO: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Determine physiological, biochemical and morphological mechanisms of susceptibility and resistance of plant cultivars to air pollutants, and determinewhether these are affected by interactions with biotic factors in the environment. Identify the genetic mechanisms of resistance of plant cultivars to air pollutants. Develop air pollutant resistant plant material.

Approach: Examine the photosynthetic and respiratory processes of resistant and susceptible cultivars of tobacco, soybean and wheat. Survey isoenzymes producedby resistant and susceptible lines using electrophoretic profiles to aide in locating potential genetic markers. Isolate and incorporate resistant genetic material in the plant breeding program.

Progress: 77/10 to 83/09. Over the life of B-127, research was focused on the following four areas: Examining the activity of peroxidase as a gene marker for ozone tolerance in tobacco; examining the effects of ozone on wheat cultivars grown in Maryland; the impact of ozone on the growth dynamics of tobacco, and investigating the effects of O(3) and SO(2) on nitrogen fixation and yields of soybean cultivars. The following conclusions may be drawn from the investigators: Peroxidase activity showed significant stimulations following exposure to ozone both in greenhouse and field studies; however, the magnitude of stimulation was variable across environments which suggest that it is too variable for use as a pollution tolerance screening device. Yields and grain quality were reduced in wheats exposed during flowering or throughout the growth of the plants. Significant differences were found among cultivars grown in Maryland. This research is being continued. Ozone was observed to significantly reduce the relative growth rates in four cultivars which differed significantly in visual responses. Therefore, ozone tolerance ratings should consider growth in addition to visual leaf injury in breeding programs. Total nodule activity in soybeans was reduced following exposures to O(3) and SO(2). Also, grain yields were significantly reduced in field studies following pollution treatments at two growth stages.

Publications: 77/10 to 83/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

17.002 CRIS0091511
**REDUCING THE INFLUENCE OF AIR POLLUTION ON
 PLANT PRODUCTIVITY**

MULCHI C L; AYCOCK M K JR; SAMMONS O S;
 Agronomy; University of Maryland, College Park,
 MARYLAND 20742.
 Proj. No.: MD-B-144 Project Type: HATCH
 Agency IO: CSRS Period: 01 OCT 83 to 31 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality.

Approach: To examine the response of two Maryland tobacco cultivars to full season exposures to chronic (7 + 1 pphm) or acute (12 + 1 pphm) ozone. To examine the effects of 10 pphm O3 or 10 pphm SO2 on grain quality characteristics in four wheat cultivars. To investigate physiological processes which may be used as genetic markers following exposures of crop seedlings to pollutants.

Progress: 84/01 to 84/12. Four cultivars of soft red winter wheat were grown in open-top chambers at USOA-BARC in 1984 and exposed to the following treatments: ambient air (non-chambered), carbon filtered, non-filtered (NF), and NF + 20, 40 or 80 ppb ozone. The ozone treatments were imposed 4 hr/day, 5 days/wk during the months of May and June. The NF+80 ppb O(3) treatments induced significant reductions in total dry weights, grain yields, 100 seed weight and harvest index. Compared to carbon filtered air, the NF+20, 40 and 80 ppb treatments reduced: dry weights by 0.3, 8.6 and 21.0%, respectively; grain yields by 4.3, 12.0, and 41.1%, respectively; 100 seed weight by: 5.0, 9.9, and 23.8%, respectively. Seed germination was not affected by treatments. Significant cultivar x treatment interactions were observed only for total dry weights. Grain quality evaluations are being made in cooperation with USOA. The research will be repeated in 1985. Twelve cultivars of soybeans were grown in open-top chambers and exposed full-season to carbon filtered air and non-filtered air plus 4 ppb ozone. There were four cultivars each from three maturity groups (III, IV and V). Seedlings were analyzed for relative growth rates, absolute growth rates, and net assimilation rates and grain yields were collected at maturity. As a group, the ozone treatments caused reductions of absolute growth rates of 16.4%, relative growth rates of 13.5%, net assimilation rates of 13.0% and grain yields of 11.1%.

Publications: 84/01 to 84/12
 ARMBRUSTER, J.A., and MULCHI, C.L. 1984. Response of corn and soybeans to soil vs. foliar applied salta of cooling tower origin. Jour. of Env. Quality. 13:278-282.
 JONES, A.W., MULCHI, C.L., and KENWORTHY, W.J. 1985. Influence of ozone and sulfur dioxide on nodule activity and chlorophyll content in soybean cultivars. Jour. of Env. Quality. 14 (In Press).

17.003
EXPLORATORY RESEARCH IN CHEMISTRY

CRIS0069924

ABBOTT E H; Chemistry; Montana State University, Bozeman, MONTANA 59717.
 Proj. No.: MONBO0254 Project Type: STATE
 Agency ID: SAES Period: 01 JUL 82 to 30 JUN 99

Objectives: To enable chemistry station scientists to handle miscellaneous chemical problems of interest to agriculture which frequently turn up and seem to require prompt attention. Usually these problems will require only a limited amount of work either to provide a solution or to determine whether a full scale investigation is advisable. In the latter case, a research proposal would be prepared and submitted.

Approach: Chemistry faculty who feel that they have identified a problem of immediate importance to agriculture and who wish to seek support under this project will prepare a proposal outlining the problem, its relevance to agriculture, the approach to be taken, and a budget. The proposal will be reviewed by MAES staff and the project leader will determine whether funds should be allocated to the proposed study. Scientists receiving funds from this project will follow the same reporting procedures applicable to other station projects.

Progress: 84/01 to 84/09. One concern of acid deposition is how increased acidity alters the interaction of trace metal complexes with soil materials. Laboratory studies currently in progress are investigating the interaction of a series of cadmium complexes with hydrous aluminum oxide. The ligands, nitrilotriacetic acid, ethylenediamine-diacetic acid, diethylenetriaminemonoacetic acid and triethylenetetramine are all tetradentate but provide cadmium complexes of varying charge. The interactions of these complexes with the solid material is being monitored with different of pulse polarography. To date the CdNTA system is fairly well characterized. In general hydrous aluminum oxide absorbs sizeable amounts of this complex and the process is hydrogen ion dependent. A second part of this project entails the characterization and synthesis of commercially important organic chemicals of significance to Montana Agriculture. Work completed includes the identification and study of new phytotoxins, insecticides, pheromones, antiviral chemicals, and compounds which speed plant growth. The Cardellina group is exploring the development of new agrochemicals from natural sources - terrestrial plants and marine fauna and flora. Isolation, identification and in house bioassays for plant growth regulatory, antimicrobial and insecticidal activity are the central features of this research program.

Publications: 84/01 to 84/09

ARMOLD, A. and AMEND, J. (1984) The grazing land simulator; compiled for public education. Proceedings of Laramie Conference of Great Plains Agricultural Council.

17.004* CRIS0097557
THE EFFECTS OF ATMOSPHERIC POLLUTANTS ON THE REPRODUCTION OF AGRICULTURAL CROPS

DUBAY D; STUCKY J; NEAGLE A; Botany; N Carolina State University, Raleigh, NORTH CAROLINA 27650.

Proj. No.: NC09340 Project Type: CRGO
 Agency ID: CRGO Period: 01 SEP 85 to 30 SEP 87

Objectives: Proj 8501684. Determine the direct effects of simulated acid reproduction of corn, soybean, wheat, cotton, snap bean, and tomato, determine the influence of chronic O(3) exposure on the effects of acid rain on cotton and soybean reproduction. Determine the effects of acid rain on the viability and fitness of seeds produced by treated flowers.

Approach: Flowers are exposed once to simulated rain of different acidities. Cotton and soybean are grown before and after rain treatment in chambers with charcoal-filtered air or air with added O(3). Treated flowers are scored for seed production, and seeds are tested for viability and fitness.

17.005* CRIS0046127
LOSS OF CROP PRODUCTION BY OZONE, SULFUR DIOXIDE, NITROGEN DIOXIDE AND OTHER MIXTURES

MIKSCH J P; HECK W W; Botany; N Carolina State University, Raleigh, NORTH CAROLINA 27650.

Proj. No.: 7005-20790-008-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 01 APR 80 to 30 SEP 83

Objectives: Develop a National crop loss assessment program to determine the loss of crop production by ozone, sulfur dioxide, nitrogen dioxide and their mixtures.

Approach: Determine dose-response curves for selected important economic crops (i.e. soybean, corn, wheat, oats, forages) from exposure to ambient air pollutants under field conditions. Experimental designs will utilize open-top field chambers over small field plots. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at 2 weeks from seeding. Plants will be exposed to background ozone, ambient ozone and three or four higher ozone increments for 7 hrs/day over the summer. Ozone increases will be set amounts over ambient so normal daily fluctuations will be observed. Similar designs will be used for sulfur dioxide, nitrogen dioxide and gas mixtures.

Progress: 81/01 to 81/12. Peanut ('NC-6'), soybean ('Davis', 2 designs) and cotton ('Stoneville 213') were exposed to 4 to 5 different chronic doses of ozone (O(3)) in open-top field chambers from seedling to harvest. Data were analyzed using linear regression and several three-parameter models were tested; the Weibull function was considered the best. Estimates of yield

reductions at ambient concentrations of O(3) (0.05 to 0.06 ppm for a 7-hr/day seasonal mean) were: peanut - 12 to 19%, soybean - 5 to 24% and cotton - 10 to 16%. A zonal air pollution system was developed, tested and used in the exposure of field grown peanuts. The first soybean study also used four chronic doses of sulfur dioxide (SO(2)); no interactions were found and, except at the highest concentration used, no SO(2) effects were reported. In the second soybean study, O(3) additions were constant or proportional and the amount of solar radiation interrupted by the canopy was used as a measure of growth; yield was not affected by the means of adding O(3); radiation interpreted over the growing season correlated well with plant growth dynamics. The cotton study also used four chronic doses of SO(2) and had a single replication where frusta were added to the chambers to control ingress of ambient pollutants; no interactions were found and only the highest SO(2) concentration caused a yield reduction in cotton; the addition of the frusta did not affect cotton sensitivity to O(3).

Publications: 81/01 to 81/12

- HECK, W.W., TAYLOR, O.C., ADAMS, R., BINGHAM, G., MILLER, J., PRESTON, E. and WEINSTEIN, L. 1982. Assessment of Crop Loss From Ozone. J. Air Pollut. Contr. Assoc. 32:353-361.
- HEAGLE, A.S., LETCHWORTH, M.B. and MITCHELL, C. 1983. Injury and yield responses of peanuts to chronic doses of ozone in open-top chambers. Phytopathology 73:551-555.
- HEAGLE, A.S., HECK, W.W., RAWLINGS, J.O. and PHILBECK, R.B. 1983. Effects of chronic doses of ozone and sulfur dioxide on injury and yield of soybeans in open-top field chambers. Crop Sci. 23:1984-1191.
- HECK, W.W., ADAMS, R.M., CURE, W.W., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W., RAWLINGS, J.O. and TAYLOR, O.C. 1983. A reassessment of crop loss from ozone. Environ. Sci. and Tech. 17:573-580A.
- HECK, W.W., CURE, W.W., RAWLINGS, J.O., ZARAGOZA, L.U., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W. and TEMPLE, P.J. 1984. Assessing impacts of ozone on agricultural crops: I. Overview. JAPCA 34:729-735

17.006* CRIS0047266 FIELD STUDIES OF PLANT RESPONSES TO ELEVATED CARBON DIOXIDE LEVELS

THOMAS J F; ROGERS H H; Botany; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
Proj. No.: 7009-20790-009-00S
Project Type: COOPERATIVE AGREE.
Agency ID: ARS Period: 22 JUL 81 to 30 SEP 84

Objectives: Establish dose-response relationships between various elevated CO(2) levels and crop production as well as some key crop processes.

Approach: The general approach for this work will use a plant exposure system (with open top chambers) for the generation of large-scale CO(2) test atmospheres in the field. Selected economically important crops will be exposed within the system over the growing season. The system is both cost effective and mechanically reliable over long time periods. The system further provides an environment as identical to field conditions as possible, given the above constraints. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at seeding. Plants will be exposed to ambient CO(2) and variable other set concentrations throughout their life cycle.

Progress: 81/01 to 81/12. A field program was designed and tested in 1980 to expose crop plants under field conditions to elevated levels of CO(2) (above ambient). Soybean was used as the primary test species but sweet potato was included in the last year of the study. Plants were grown in pots for the first two years and in the soil (ground) under normal field practices the last two years. Open-top field Chambers, developed to study ambient pollution effects on crop growth, were used to control the CO(2) concentrations around the test plants. Conical tops (frusta) were used to reduce ingress of outside air and make better utilization of CO(2) gas. Plants were grown from seedlings (1 or 2 weeks) to maturity under the different CO(2) regimes. Soil moisture stress was a variable several years. Studies included effects on water relations (water use efficiency), photosynthesis and movement of photosynthate, stomatal function, growth analysis, anatomical changes, growth and yield of mature plants. Elevated CO(2) during soybean growth generally resulted in: increased node number, increased water use efficiency, decrease of whole plant N to dry matter ratio in pot-grown plants, increase in root nodule mass, extra carbon fixed is partitioned to starch, increased plant weight more in water stressed than non-stressed plants, increased seed dry weight.

Publications: 81/01 to 81/12

- ROGERS, H.H., BINGHAM, G.E., THOMAS, J.F., SMITH, J.M., ISRAEL, D.W. and SURANO, K.A. 1982. Effects of long term concentration on field grown crops and trees. In: "Global Dynamics of Biospheric Carbon." pp. 9-45. Department of Energy, O19.
- DAVIS, J.M., RIORDAN, A.J. and LAWSON, R.E. 1983. A wind tunnel study of the flow field within and around open-top chambers used for air pollution studies. Bound. Layer Meteorol. 25:193-214.
- ROGERS, H.H., HECK, W.W., and HEAGLE, A.S. 1983. A field technique for the study of plant responses to elevated carbon dioxide concentrations. J. Air Pollut. Contr. Assoc. 33:42-44.
- ROGERS, H.H., BINGHAM, G.E., CURE, J.D., SMITH, J.M. and SURANO, K.A. 1983. Responses of selected plant species to elevated CO(2) in the field. J. Environ. Qual. 12:569-574.
- ROGERS, H.H., THOMAS, J.F. and BINGHAM, G.E. 1983. Responses of agronomic and forest species to elevated atmospheric carbon

dioxide. Science 220:428-429.

17.007* CRIS0047610
RESPONSE OF PLANTS TO MIXTURES OF SELECTED
ATMOSPHERIC CONTAMINANTS

HUANG J; REINERT R A; Plant Pathology; N
 Carolina State University, Raleigh, NORTH
 CAROLINA 27650.

Proj. No.: 7013-20790-012-005

Project Type: COOPERATIVE AGREE.

Agency ID: ARS Period: 21 APR 82 to 30 SEP 84

Objectives: Develop a greenhouse exposure system for studying the effects of up to three gaseous contaminants in various combinations. Determine short and long-term effects of gas mixtures on plant growth and productivity in both greenhouse and field exposures.

Approach: Design a multiple chamber greenhouse exposure system for the study of pollutant mixtures. Determine ratios and combinations of gaseous pollutants that occur in ambient air. Design experiments to include the above mixtures and their multiple so as to develop response surfaces for various gas mixtures. Determine plant response to these mixtures. Plan selected studies to help determine the mechanism of plant response and resistance.

Progress: 82/04 to 84/09. Systems were developed for studying the effect of gaseous contaminants ozone (O₃), sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) on crop plants. These systems included: 1) a charcoal filtered air (CF) and non-filtered air (NF) greenhouse section, 2) 20 plant exposure chambers 4 ft dia. by 4 1/2 ft tall placed in a CF 30 x 40 greenhouse section and facilitated with a pollutant dispensing and monitoring system, and 3) 12 rotating tables placed in a 20 x 40 ft CF greenhouse section for exposing plants to simulated rain at different pH levels. Numerous plant species were grown in both CF and NF greenhouse air and developed O₃ injury in the NF air but not in the CF air. Soybean, cv. Bragg, were grown and exposed to NO₂ (0.0, 0.1, or 0.2 ppm) and SO₂ (0.0, 0.2, and 0.3 ppm) singly and in combination. Plants were harvested after either 5 or 15 exposures. Leaf discs from trifoliate leaves were sampled for ribulose biphosphate carboxylase (RuBPC) activity and protein concentration. After 15 exposures to SO₂ RuBPC enzyme activity increased and then decreased in a curvilinear manner in the younger leaf tissue and decreased in a linear manner in older leaf tissue. Stem and leaf dry weight was significantly reduced by SO₂ while root weight was significantly reduced by mixtures of SO₂ and NO₂. Experiments were initiated to study the uptake and metabolism of CO₂ in soybean leaves following exposure to SO₂ and NO₂, alone and in combination.

Publications: 82/04 to 84/09

KLARER, C.I., REINERT, R.A. and HUANG, J.S.
 1984. Effects of sulfur dioxide and nitrogen dioxide on vegetative growth of soybeans. Phytopathology 74:1104-1106.

KLARER, C.I., HUANG, J.S. and REINERT, R.A.
 1984. Changes in ribulose biphosphate carboxylase activity, protein concentration and vegetative growth of soybeans over time in response to sulfur dioxide and nitrogen dioxide.

REINERT, R.A. 1984. Plant response to air pollutant mixtures. Ann. Rev. Phytopath. 22:421-422.

KLARER, C.I. 1983. Effects of sulfur dioxide and nitrogen dioxide singly and in combination over time, on ribulose biphosphate carboxylase activity in vegetative growth of soybean. MS. degree, Department of Plant Pathology.

17.008 CRIS0079679
PRODUCTION OF BREEDER SEED OF CEREAL AND FORAGE CROPS

MOSS D N; Crop Science; Oregon State University, Corvallis, OREGON 97331.
 Proj. No.: ORE00230 Project Type: STATE
 Agency ID: SAES Period: 15 APR 79 to 01 JAN 99

Objectives: Provide a source of nuclear and breeders seed of cereals, grasses and legumes. OR.

Approach: The plant breeders will select heads and individual plants from the appropriate breeding lines. The heads and plants will be threshed and planted as individual rows or lines. The plantings will then be carefully rogued for off-types and the seed bulked at harvest time.

Progress: 84/01 to 84/12. The primary task under this project this year has been to analyze and summarize data from several years study on the effects of acid rain on field crops. Neither wheat nor potatoes showed any yield reduction when the crops were exposed to simulated acid rain in the pH range 3.5 to 5.5. Maize was the only field grown crop which showed any effect of acid rain on yield. Maize had a suppressed yield at pH 4.0 in two of three years. The most extensive experiments on maize were done in 1982, and there was no effect on yield of any treatment in that year. We concluded that acid rain is not likely to be a significant problem for crop plant production, and the fertilizer elements (S and N) contained in the rain may enhance yields in poorly fertilized crops.

Publications: 84/01 to 84/12

MOSS, D.N. 1984. Photosynthesis, respiration, and photorespiration in higher plants. In PHYSIOLOGICAL BASIS OF CROP GROWTH AND DEVELOPMENT. American Society of Agronomy, Madison, WI.

17.009*
PHYSIOLOGY OF WHEAT AND POTATOES

CRIS0092464

MOSS D N; Crop Science; Oregon State University, Corvallis, OREGON 97331.
 Proj. No.: ORE00390 Project Type: HATCH
 Agency ID: CSRS Period: 01 MAR 84 to 31 DEC 88

Objectives: Define physiological traits limiting yield and those useful in breeding high yielding varieties of wheat and potatoes.

Approach: Studies will be conducted at various levels of plant organization (molecular, subcellular, cellular, tissue, organ, plant, community). The information will be summarized in a logical framework using the power of modern computers. Data from a lower level will generally be used in models to predict response at the next higher level of organization.

Progress: 84/01 to 84/12. The primary task under this project this year has been to analyze and summarize data from several years study on the effects of acid rain on field crops. Neither wheat nor potatoes showed any yield reduction when the crops were exposed to simulated acid rain in the pH range 3.5 to 5.5. Maize was the only field grown crop which showed any effect of acid rain on yield. Maize had a suppressed yield at pH 4.0 in two of three years. The most extensive experiments on maize were done in 1982, and there was no effect on yield of any treatment in that year. We concluded that acid rain is not likely to be a significant problem for crop plant production, and the fertilizer elements (S and N) contained in the rain may enhance yields in poorly fertilized crops.

Publications: 84/01 to 84/12

MOSS, D.N. 1984. Photosynthesis, respiration and photorespiration in higher plants. In Physiological Basis of Crop Growth and Development. American Society of Agronomy, Madison, WI.

17.010*
SOIL FERTILITY, MANAGEMENT, AND PLANT NUTRITION FOR FORAGE AND HORTICULTURAL CROP PRODUCTION IN EAST TEXAS

CRIS0076369

HABY V A; Research & Extension Center; Texas A&M University, Overton, TEXAS 75684.
 Proj. No.: TEX06320 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 83 to 30 JUN 88

Objectives: Determine the influence of varying levels of soil acidity on the availability of soil and applied fertilizer nutrients for roses and warm and cool season grasses and legumes. Evaluate the efficiency of applied N and that fixed by leguminous plants for small grains and warm season grass production. Evaluate the influence of K fertilizers on disease reduction in small grains and Coastal bermudagrass. Determine the soil fertility and fertilizer requirements of blueberries and peaches under East Texas conditions. Determine the effect of acid rain on East Texas soils and crops. Relate crop responses from various plant nutrient applications to the soil test level of

those nutrients in order to improve the predictability of the soil test for fertilizer needs.

Approach: Field studies on bench mark soils of East Texas will be used to evaluate the responses of soils and crops to fertilizer nutrients and limestone. Greenhouse research will support the field studies. Soil and plant analyses in the laboratory will help evaluate field and greenhouse experiment responses. Data will be evaluated by appropriate statistical analyses.

Progress: 84/01 to 84/12. Ryegrass yield responses to limestone rates of 0, 672, and 3810 kg/ha were 3119, 5063, and 6020 kg/ha, respectively. Yields increased from 4120 to 5629 kg/ha as P rate increased from 0 to 240 kg/ha, respectively. Winter wheat grain yield increased from 1463 to 4016 kg/ha with N rate increments from 0 to 224 kg/ha, respectively, but yield differences due to the N sources ammonium nitrate, urea, and urea phosphate were negligible. Prior year growth of subterranean clover contributed the equivalent of 70 kg N/ha to the wheat. Winter wheat grain yields were similar for KCl and K(2)SO(4) potassium sources. Yield response to K rate increases was not statistically significant. A versatile, three-point hitch, tractor-mounted applicator was designed and constructed to dispense fluid fertilizers from containers pressurized by a tractor-mounted and powered pressure system. This applicator is used to evaluate dribble band spacings, methods of application, rates, and combinations of fluid fertilizers applied to Coastal bermudagrass. A severe summer drought restricted growth but grass yield from the three harvests was significantly increased from 11,500 to 15,928 kg/ha as N rate increased from 45 to 135 kg/ha at site one, and from 8064 to 10,080 at site two which is a less responsive soil. Banded urea-ammonium nitrate at spacings of 18, 36, 53, and 71 cm between bands, and method of application had no significant effect on grass yield. Nitrogen source comparisons yielded mixed results between both sites.

Publications: 84/01 to 84/12

NELSON, L.R., HABY, V.A., BATEMAN, C. and KREJSA B. 1984. Accumulation of Al, Ca, Mg, Mn, K and P in annual ryegrass due to soil flooding. American Society of Agronomy Abstracts.

BRANDT, J.E., HONS, F.M. and HABY, V.A. 1984. The effect of nitrogen management on the yield and nitrogen uptake efficiency of soft red winter wheat. American Society of Agronomy abstracts.

HABY, V.A., DAVIS, J.V. and SMITH, K.L. 1984. A versatile fluid fertilizer applicator for field research. American Society of Agronomy Abstracts.

CM 18 OTHER SMALL GRAINS

18.001* CRIS0074176
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE-WATERS

WALKER J T; Plant Pathology; Georgia Agric Expt Station, Experiment, GEORGIA 30212.
 Proj. No.: GED01249 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 JAN 83

Objectives: Establishing an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Determining the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to the total atmospheric deposition in various states and regions in the United States. Organizing research in the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters; etc.

Approach: Establish a collector of the wet/dry type (Volchok and Graveson) at an approved collection site and ship samples on scheduled basis to a central analytical laboratory for analysis. Determine the contribution and importance of these depositions to the state and region in terms of agricultural productivity (Agronomic crops) and effects on vegetation (trees, shrubs, or turf) in the rural and urban environments, specifically in terms of diseases and contribution to minor element requirements.

Progress: 77/12 to 83/01. Using the protocol of the NADP guidelines, an Aerochem Metric Precipitation Collector (Model 201) was installed in the Georgia piedmont in October, 1978. A recording rain gauge, wind vane-anemometer, and particulate sampler was operated at the site. Ozone levels were monitored elsewhere. Precipitation samples were analyzed by the Central Analytical Laboratory. Particulates (TSP) were determined on a filter exposed for 24 h every 6 days. The effects of acidified water on a variety of plants under growth chamber, greenhouse, and field conditions were determined. The effect of aqueous solutions at different pHs on subsequent seed germination was studied. Over the 1979-81 period, the highest ionic constituent in rain was sulfate with an average of 2.6-3.5 mg/1/yr. followed by nitrate with 1.0 to 1.3 mg./1. The 3-yr. average for 9 ions in mg/1, was: Ca 0.24, Mg 0.13, K 0.18, Na 0.45, NH₄ 0.33, NO₃ 1.2, Cl 0.46, SO₄ 2.99, PO₄ 0.06. The lowest average pH occurred in the 2nd and 3rd calendar quarter, with values ranging from a low of 4.12 to high of 4.96. Average TSPs for 1979, 1980, and 1981, were 37.2, 38.7, and 46.7 mg./m³, respectively. Ozone averaged 3.6 ppbm. Lead averaged .052 to .073 mg./m³ annually. Some plant species and cvs were injured by acidic mists at pH 1.8, but few plants were affected by pH 2.6 sprays. Grass seed germination was decreased by pH 2.6 solutions, but alfalfa, corn and cucumber were unaffected. Germination of some soybean cvs was

reduced at pH 2.6.

Publications: 77/12 to 83/01
 NO PUBLICATIONS REPORTED THIS PERIOD.

18.002* CRIS0046127
LOSS OF CROP PRODUCTION BY OZONE, SULFUR DIOXIDE, NITROGEN DIOXIDE AND OTHER MIXTURES

MIKSCHE J P; HECK W W; Botany; N Carolina State University, Raleigh, NORTH CAROLINA 27650.

Proj. No.: 7005-20790-008-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 01 APR 80 to 30 SEP 83

Objectives: Develop a National crop loss assessment program to determine the loss of crop production by ozone, sulfur dioxide, nitrogen dioxide and their mixtures.

Approach: Determine dose-response curves for selected important economic crops (i.e. soybean, corn, wheat, oats, forages) from exposure to ambient air pollutants under field conditions. Experimental designs will utilize open-top field chambers over small field plots. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at 2 weeks from seeding. Plants will be exposed to background ozone, ambient ozone and three or four higher ozone increments for 7 hrs/day over the summer. Ozone increases will be set amounts over ambient so normal daily fluctuations will be observed. Similar designs will be used for sulfur dioxide, nitrogen dioxide and gas mixtures.

Progress: 81/01 to 81/12. Peanut ('NC-6'), soybean ('Davis', 2 designs) and cotton ('Stoneville 213') were exposed to 4 to 5 different chronic doses of ozone (O₃) in open-top field chambers from seedling to harvest. Data were analyzed using linear regression and several three-parameter models were tested; the Weibull function was considered the best. Estimates of yield reductions at ambient concentrations of O₃ (0.05 to 0.06 ppm for a 7-hr/day seasonal mean) were: peanut - 12 to 19%, soybean - 5 to 24% and cotton - 10 to 16%. A zonal air pollution system was developed, tested and used in the exposure of field grown peanuts. The first soybean study also used four chronic doses of sulfur dioxide (SO₂); no interactions were found and, except at the highest concentration used, no SO₂ effects were reported. In the second soybean study, O₃ additions were constant or proportional and the amount of solar radiation interrupted by the canopy was used as a measure of growth; yield was not affected by the means of adding O₃; radiation interpreted over the growing season correlated well with plant growth dynamics. The cotton study also used four chronic doses of SO₂ and had a single replication where frusta were added to the chambers to control ingress of ambient pollutants; no interactions were found and only the highest SO₂ concentration caused a yield reduction in cotton; the addition of the frusta did not affect cotton sensitivity to

0(3).

Publications: 81/01 to 81/12

- HECK, W.W., TAYLOR, D.C., ADAMS, R., BINGHAM, G., MILLER, J., PRESTON, E. and WEINSTEIN, L. 1982. Assessment of Crop Loss From Ozone. J. Air Pollut. Contr. Assoc. 32:353-361.
- HEAGLE, A.S., LETCHWORTH, M.B. and MITCHELL, C. 1983. Injury and yield responses of peanuts to chronic doses of ozone in open-top chambers. Phytopathology 73:551-555.
- HEAGLE, A.S., HECK, W.W., RAWLINGS, J.D. and PHILBECK, R.B. 1983. Effects of chronic doses of ozone and sulfur dioxide on injury and yield of soybeans in open-top field chambers. Crop Sci. 23:1984-1191.
- HECK, W.W., ADAMS, R.M., CURE, W.W., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W., RAWLINGS, J.D. and TAYLOR, D.C. 1983. A reassessment of crop loss from ozone. Environ. Sci. and Tech. 17:573-580A.
- HECK, W.W., CURE, W.W., RAWLINGS, J.D., ZARAGOZA, L.J., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W. and TEMPLE, P.J. 1984. Assessing impacts of ozone on agricultural crops: I. Overview. JAPCA 34:729-735

18.003* CRIS0047266
FIELD STUDIES OF PLANT RESPONSES TO ELEVATED CARBON DIOXIDE LEVELS

THOMAS J F; ROGERS H H; Botany; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: 7009-20790-009-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 22 JUL 81 to 30 SEP 84

Objectives: Establish dose-response relationships between various elevated CO(2) levels and crop production as well as some key crop processes.

Approach: The general approach for this work will use a plant exposure system (with open top chambers) for the generatio of large-scale CO(2) test atmospheres in the field. Selected economically important crops will be exposed within the system over the growing season. The system is both cost effective and mechanically reliable over long time periods. The system further provides an environment as identical to field conditions as possible, given the above constraints. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at seeding. Plants will be exposed to ambient CO(2) and variable other set concentrations throughout their life cycle.

Progress: 81/01 to 81/12. A field program was designed and tested in 1980 to expose crop plants under field conditions to elevated levels of CO(2) (above ambient). Soybean was used as the primary test species but sweet potato was included in the last year of the study. Plants were grown in pots for the first two years and in the soil (ground) under normal field practices the last two years. Open-top

field Chambers, developed to study ambient pollution effects on crop growth, were used to control the CO(2) concentrations around the test plants. Conical tops (frusta) were used to reduce ingress of outside air and make better utilization of CO(2) gas. Plants were grown from seedlings (1 or 2 weeks) to maturity under the different CO(2) regimes. Soil moisture stress was a variable several years. Studies included effects on water relations (water use efficiency), photosynthesis and movement of photosynthate, stomatal function, growth analysis, anatomical changes, growth and yield of mature plants. Elevated CO(2) during soybean growth generally resulted in: increased node number, increased water use efficiency, decrease of whole plant N to dry matter ratio in pot-grown plants, increase in root nodule mass, extra carbon fixed is partitioned to starch, increased plant weight more in water stressed than non-stressed plants, increased seed dry weight.

Publications: 81/01 to 81/12

- ROGERS, H.H., BINGHAM, G.E., THOMAS, J.F., SMITH, J.M., ISRAEL, D.W. and SURANO, K.A. 1982. Effects of long term concentration on field grown crops and trees. In: "Global Dynamics of Biospheric Carbon." pp. 9-45. Department of Energy, 019.
- DAVIS, J.M., RIORDAN, A.J. and LAWSON, R.E. 1983. A wind tunnel study of the flow field within and around open-top chambers used for air pollution studies. Bound. Layer Meteorol. 25:193-214.
- ROGERS, H.H., HECK, W.W., and HEAGLE, A.S. 1983. A field technique for the study of plant responses to elevated carbon dioxide concentrations. J. Air Pollut. Contr. Assoc. 33:42-44.
- ROGERS, H.H., BINGHAM, G.E., CURE, J.D., SMITH, J.M. and SURANO, K.A. 1983. Responses of selected plant species to elevated CO(2) in the field. J. Environ. Qual. 12:569-574.
- ROGERS, H.H., THOMAS, J.F. and BINGHAM, G.E. 1983. Responses of agronomic and forest species to elevated atmospheric carbon dioxide. Science 220:428-429.

18.004* CRIS0047610
RESPONSE OF PLANTS TO MIXTURES OF SELECTED ATMOSPHERIC CONTAMINANTS

HUANG J; REINERT R A; Plant Pathology; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: 7013-20790-012-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 21 APR 82 to 30 SEP 84

Objectives: Develop a greenhouse exposure system for studying the effects of up to three gaseous contaminants in varaious combinations. Determine short and long-term effects of gas mixtures on plant growth and productivity in both greenhouse and field exposures.

Approach: Design a multiple chamber greenhouse exposure system for the study of pollutant mixtures. Determine ratios and combinations of gaseous pollutants that occur in ambient air.

Design experiments to include the above mixtures and their multiple so as to develop response surfaces for various gas mixtures. Determine plant response to these mixtures. Plan selected studies to help determine the mechanism of plant response and resistance.

Progress: 82/04 to 84/09. Systmes were developed for studying the effect of gaseous contaminants ozone (O₃), sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) on crop plants. These systmes included: 1) a charcoal filtered air (CF) and non-filtered air (NF) greenhouse section, 2) 20 plant exposure chambers 4 ft dia. by 4 1/2 ft tall placed in a CF 30 x 40 greenhouse section and facilitated with a pollutant dispensing and monitoring system, and 3) 12 rotating tables place in a 20 x 40 ft CF greenhouse section for exposing plants to simulated rain at different pH levels. Numerous plant species were grown in both CF and NF greenhouse air and developed O₃ injury in the NF air but not in the CF air. Soybean, cv. Bragg, were grown and exposed to NO₂ (0.0, 0.1, or 0.2 ppm) and SO₂ (0.0, 0.2, and 0.3 ppm) singly and in combination. Plants were harvested after either 5 or 15 exposures. Leaf discs from trifoliolate leaves were sampled for ribulose bisphosphate carboxylase (RuBPC) activity and protein concentration. After 15 exposures to SO₂ RuBPC enzyme activity increased and then decreased in a curvilinear manner in the younger leaf tissue and decreased in a lianear manner in older leaf tissue. Stem and leaf dry weight was significantly reduced by SO₂ while root weight was significantly reduced by mixtures of SO₂ and NO₂. Experiments were initiated to study the uptake and metabolism of CO₂ in soybean leaves following exposure to SO₂ and NO₂, alone and in combination.

Publications: 82/04 to 84/09

- KLARER, C.I., REINERT, R.A. and HUANG, J.S. 1984. Effects of sulfur dioxide and nitrogen dioxide on vegetative growth of soybeans. *Phytopathology* 74:1104-1106.
- KLARER, C.I., HUANG, J.S. and REINERT, R.A. 1984. Changes in ribulose bisphosphate carboxylase activity, protein concentration and vegetative growth of soybeans over time in response to sulfur dioxide and nitrogen dioxide.
- REINERT, R.A. 1984. Plant response to air pollutant mixtures. *Ann. Rev. Phytopath.* 22:421-422.
- KLARER, C.I. 1983. Effects of sulfur dioxide and nitrogen dioxide singly and in combination over time, on ribulose bisphosphate carboxylase activity in vegetative growth of soybean. MS. degree, Department of Plant Pathology.

Objectives: Provide a source of nuclear and breeders seed of cereals, grasses and legumes. OR.

Approach: The plant breeders will select heads and individual plants from the appropriate breeding lines. The heads and plants will be threshed and planted as individual rows or lines. The plantings will then be carefully rogued for off-types and the seed bulked at harvest time.

Progress: 84/01 to 84/12. The primary task under this project this year has been to analyze and summarize data from several years study on the effects of acid rain on field crops. Neither wheat nor potatoes showed any yield reduction when the crops were exposed to simulated acid rain in the pH range 3.5 to 5.5. Maize was the only field grown crop which showed any effect of acid rain on yield. Maize had a suppressed yield at pH 4.0 in two of three years. The most extensive experiments on maize were done in 1982, and there was no effect on yield of any treatment in that year. We concluded that acid rain is not likely to be a significant problem for crop plant production, and the fertilizer elements (S and N) contained in the rain may enhance yields in poorly fertilized crops.

Publications: 84/01 to 84/12

- MOSS, O.N. 1984. Photosynthesis, respiration, and photorespiration in higher plants. In *PHYSIOLOGICAL BASIS OF CROP GROWTH AND DEVELOPMENT*. American Society of Agronomy, Madison, WI.

18.005* CRIS0079679
PRODUCTION OF BREEDER SEED OF CEREAL AND FORAGE CROPS

MOSS O N; Crop Science; Oregon State University, Corvallis, OREGON 97331.
 Proj. No.: ORE00230 Project Type: STATE
 Agency ID: SAES Period: 15 APR 79 to 01 JAN 99

CM 20 FORAGE CROPS

20.001* CRIS0089156
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATER, AND
MATERIALS**

WALKER J T; Plant Pathology; Georgia Agric
Expt Station, Experiment, **GEORGIA** 30212.
Proj. No.: GE001341 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish, the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings and other materials in machinery or structure.

Approach: The Georgia collection site has been operational since October, 1978, and will continue as part of the NADP program. Data obtained is available to all interested scientists. Efforts research on agricultural and horticultural crops will encompass general growth responses including biomass and yield from simulated rain treatments and symptomatology. Influence of simulants on endemic pathogens of commercial crops will be determined in growth chambers and field plots. Cooperative studies with scientists in other departments and agencies will be initiated.

Progress: 84/01 to 84/12. The 1983 quarterly volume weighted average pH of rain falling at the Georgia NADP/NTN site was 4.37, 4.71, 4.57 and 4.57. The six month average for 1984 is 4.50. The 1983 rainfall was 112.35 cm; for the first six months of 1984 it is 49.75 cm. Sulfate and nitrate remain the principle rainfall constituents, with deposition rates in 1984 comparable to those in 1983; six month sulfate rates were 878.6 and 823.3, respectively. Nitrate (NO₃) rates were 467.7 and 453.2. Total suspended particulates (ug TSP/M-3) averaged 23.7 for 1983, and 35.8 for nine months of 1984. Lead levels assayed on hi-vol filters remain low (0.03 mg/m³). Daily O₃ concentrations averaged 2.86 for May through October. A portable rain simulator, using Bete Simulated Rain Nozzles and PVC pipe, was constructed. Trials revealed that the 2.5 cm pipe with pumping system at 5 or 10 psi delivered 2.1 gals per minute to adequately wet soybean foliage. This deposition rate approximates 0.64 cm/h. To evaluate the system, Davis soybeans were planted on June 18 in a field previously fertilized with 2173 kg. of 5-10-15 per hectare. Lasso was applied after planting and the field irrigated on June 19 to enhance germination. Simulated rain (pH 3.5) was applied to soybeans in each of three 2.4mx2.4m plots at 2 rates, 208 or 416 liters, on four dates from August 21 to September 28. Plants in each plot were counted and bean yield determined at maturity. No visible injury was detected on soybean foliage.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

20.002 CRIS0092338
**EFFECTS OF SIMULATED ACID PRECIPITATION
CONDITIONS ON ROOT NODULATION IN SOYBEAN AND
ALFALFA**

KAUL K; Community Research Service; Kentucky State University, Frankfort, **KENTUCKY** 40601.
Proj. No.: KY.X-10-84-01P Project Type: 1890/T
Agency ID: CSRS Period: 10 FEB 84 to 09 FEB 88

Objectives: Study of growth of *R. japonicum* and *R. meliloti* strains isolated from Kentucky soils and certain other commercially available strains under high S, N, Al, and Fe and low Ca, K, Mo, and P. Assessment of the ability of the above mentioned bacterial strains to nodulate their host plants in laboratory and greenhouse under the above mentioned nutritional conditions. Assessment of the ability of nodules formed under simulated acid deposition conditions to fix atmospheric nitrogen. Assessment of the effects of simulated acid deposition conditions on soybean and alfalfa and recommendations regarding the best suited varieties of these crop plants and strains of *Rhizobium*.

Approach: Experiments will be done to determine the effects of acid rain on bacterial nodulation in roots of soybean and alfalfa. Effects of certain simulated acid rain conditions will be determined on root nodulating bacteria, the process of nodulation, and the ability of nodules to fix atmospheric nitrogen.

Progress: 84/02 to 84/12. Four strains of *Rhizobium japonicum* and four strains of *Rhizobium meliloti* were obtained from Nitrogen Fixation Laboratory of U.S. Department of Agriculture. In addition cultures of *Rhizobium* were isolated from root nodules of Essex and Cumberland varieties of soybean and Apalo variety of alfalfa from fields in central Kentucky. All of the above cultures are being maintained on yeast extract/mannitol medium. Purchase of all major pieces of equipment necessary for the research in this project has been completed. A co-investigator has been selected and he will be starting work on February 1, 1985.

Publications: 84/02 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

20.003* CRIS0074070
**REDUCING THE INFLUENCE OF AIR POLLUTION ON
PLANT PRODUCTIVITY**

MANNING W J; FEDER W A; Plant Pathology; University of Massachusetts, Amherst, **MASSACHUSETTS** 01003.
Proj. No.: MAS00434 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine

mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors. To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: The separate and combined effects of ozone and sulfur dioxide and acidic deposition on germination, growth, and development of coniferous and deciduous tree seedlings will be determined. Similar studies will involve yield and quality of alfalfa cultivars. Pollen/stigma interactions, in the presence of O(3), SO(2), Pb and Cd will be studied to determine whether reproduction of crop plant and tree species are affected. Effects of O(3), SO(2) and acidic deposition on alfalfa and tree seedling germination, predisposition to seedling diseases and mycorrhizal formation will be studied. Interaction of pollutants and pollen populations will be determined to describe pollutant response diversity between species and cultivars of those species.

Progress: 83/10 to 84/09. Early maturing soybean P.I. 180.499 (susceptible) and P.I. 161.989 (resistant) were selected for their reactions to ambient and controlled foliar ozone injury. A factorial-split plot experiment was conducted to determine the effects of ozone exposure (6 pphm, 6 hrs/day, 5 days/wk), soil infestation with *Fusarium oxysporum* (500 cfu/g soil dw.) and cultivar susceptibility to ozone in plastic greenhouses. Plant dry weights were reduced by ozone 24% with the susceptible line and 11% with the resistant line. Ozone injury was increased by infesting soil with *Fusarium*, but ozone had no apparent effect on root rot. Ozone and *Fusarium* reduced relative growth rate of the susceptible line, and this was due to a lower unit leaf rate and not a lower leaf area ratio. Fourteen alfalfa cultivars were screened for susceptibility to ozone (O(3)). Four-week-old seedlings were exposed to 6-8 pphm O(3) in a greenhouse for 4 weeks, and compared to seedlings grown in a carbon filtered air greenhouse for the same period. O(3) caused a significant depression for both fresh and dry weights for Buffalo, Iroquois, Oneida, Team and Vernal. Apollo II, Honeyoye, Saranac AR and Vanguard were less affected. Dry wt reductions ranged from 0.5% to 69%, and fresh weights were reduced from 8% to 77%. In most cases, a cultivar's visual injury rating correlated with the mean weight reduction. These results suggest that O(3) may decrease alfalfa growth in the Northeast.

Publications: 83/10 to 84/09

- DAMICONE, J.P. 1984. Effects of ozone and *Fusarium oxysporum* alone and in combination on growth of early maturing soybean lines. *Phytopathology* 74:843.
COOLEY, D.R. and MANNING, W.J. 1984. Differences in alfalfa cultivar

**20.004* CRIS0066186
CROP AND ORNAMENTAL PLANT TOLERANCE TO SULFUR DIOXIDE AND OZONE AIR POLLUTANT EXPOSURE**

BOOTH J A; Entomology & Plant Pathology; New Mexico State University, Las Cruces, NEW MEXICO 88003.

Proj. No.: NM-1-3-42220 Project Type: STATE
Agency ID: SAES Period: 01 JUL 82 to 30 JUN 84

Objectives: Complete studies now in progress re. effects of SO(2) on pecan nut quality. Determine differences in susceptibility to ozone SO(2), and mixtures of the two among commercial cultivars of alfalfa, chile pepper, and cotton. Identify and isolate pollution tolerant individuals through selections from large populations of alfalfa representing many cultivars.

Approach: Pecan nut quality alterations resulting from exposure to 3.0 ppm-hrs of SO(2) will be determined by measurement of nut weight, volume, density, meat wt., meat protein and liquid quantity. Treatments will be made biweekly throughout the 1982 season. Large numbers of plants of cultivars of alfalfa, cotton and chile pepper will be exposed to SO(2), ozone, and mixtures of the two gases in order to identify those which show tolerance to one or both of the gases. Vegetative propagation of tolerant lines will be used to isolate promising germ plasm for use in genetic improvement programs. The technique of convert sulfits to sulfate. Vegetative propagation will be used to isolate promising germ plasm for use in improvement programs.

Progress: 84/01 to 84/06. On December 20, 1983 the greenhouse housing the SO(2) treatment facility, and all of the isolated selections of alfalfa which showed some degree of tolerance to SO(2) exposure, were lost in a fire. In the subsequent months, especially considering the high cost of replacement of the facility, the decision was made to terminate this project and change the research direction. Existing data which was complete enough for publication was assembled, and at this point in time it appears that two manuscripts having to do with SO(2) effects on pecan nut retention and quality will be submitted for journal publication. The alfalfa SO(2-) tolerance research had not progressed sufficiently for publishable data to be accumulated.

Publications: 84/01 to 84/06
NO PUBLICATIONS REPORTED THIS PERIOD.

**20.005 CRIS0092134
GAINS, LOSSES AND MANAGEMENT OF SOIL NITROGEN**

ALEXANDER M; Agronomy; Cornell University, Ithaca, NEW YORK 14853.
Proj. No.: NYC-125447 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To assess the magnitude of and determine factors affecting losses and gains of soil nitrogen.

Approach: The significance of soil stresses on N(2) fixation will be evaluated by assessing the population changes in soil of Rhizobium strains selected for their ability to cope with these stresses under laboratory conditions or in the presence of inhibitors designed to selectively inhibit competitors or predators that may affect the rhizobia. Enumeration of the bacteria will be facilitated by the availability of a method to count these organisms even though their numbers are less than that of many other soil bacteria. The method relies on the development of mutants of Rhizobium able to grow on media containing inhibitory chemicals in concentrations preventing the growth of other bacteria. Once the stresses are defined and rhizobia tolerant to them are obtained or means of overcoming the stresses are established (e.g., selective inhibitors for competitors or antagonists), the gains in soil by these legume-Rhizobium combinations will be measured.

Progress: 84/01 to 84/12. The inhibition of N mineralization in 12 cks Adirondack soils by acid rain did not occur during incubation following the exposure period, and mineralization often was enhanced; this may result from the accumulation of potentially mineralizable N because of an inhibition of microorganisms during the exposure period. The increased N in acidic rain sometimes is equivalent to the reduced N mobilized during the exposure period. N mineralization in soils rich in organic matter is less susceptible to inhibition by acid rain than the process in soils poor in organic matter. The data suggest that the protection by organic matter may result from its prevention of short-term fluctuations in pH of the soil solution.

Publications: 84/01 to 84/12

CHANG, F.H. and ALEXANDER, M. 1984. Effect of simulated acid precipitation on decomposition and leaching of organic carbon in forest soils. *Soil Sci.* 138:226-234.

KLEIN, T.M., NOVICK, N.J., KREITINGER, J.P. and ALEXANDER, M. 1984. Simultaneous inhibition of carbon and nitrogen mineralization in a forest soil by simulated acid precipitation. *Bull. Environ. Contam. Toxicol.*

NOVICK, N.J., KLEIN, T.M. and ALEXANDER, M. 1984. Effect of simulated acid precipitation on nitrogen mineralization and nitrification in forest soils. *Water Air Soil Pollut.* 23: 317-330.

20.006* CRIS0046127
LOSS OF CROP PRODUCTION BY OZONE, SULFUR
DIOXIDE, NITROGEN DIOXIDE AND OTHER MIXTURES

MIKSCH J P; HECK W W; Botany; N Carolina
State University, Raleigh, NORTH CAROLINA
27650.

Proj. No.: 7005-20790-008-00S

Project Type: COOPERATIVE AGREE.

Agency ID: ARS Period: 01 APR 80 to 30 SEP 83

Objectives: Develop a National crop loss assessment program to determine the loss of crop production by ozone, sulfur dioxide, nitrogen dioxide and their mixtures.

Approach: Determine dose-response curves for selected important economic crops (i.e. soybean, corn, wheat, oats, forages) from exposure to ambient air pollutants under field conditions. Experimental designs will utilize open-top field chambers over small field plots. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at 2 weeks from seeding. Plants will be exposed to background ozone, ambient ozone and three or four higher ozone increments for 7 hrs/day over the summer. Ozone increases will be set amounts over ambient so normal daily fluctuations will be observed. Similar designs will be used for sulfur dioxide, nitrogen dioxide and gas mixtures.

Progress: 81/01 to 81/12. Peanut ('NC-6'), soybean ('Davis', 2 designs) and cotton ('Stoneville 213') were exposed to 4 to 5 different chronic doses of ozone (O(3)) in open-top field chambers from seedling to harvest. Data were analyzed using linear regression and several three-parameter models were tested; the Weibull function was considered the best. Estimates of yield reductions at ambient concentrations of O(3) (0.05 to 0.06 ppm for a 7-hr/day seasonal mean) were: peanut - 12 to 19%, soybean - 5 to 24% and cotton - 10 to 16%. A zonal air pollution system was developed, tested and used in the exposure of field grown peanuts. The first soybean study also used four chronic doses of sulfur dioxide (SO(2)); no interactions were found and, except at the highest concentration used, no SO(2) effects were reported. In the second soybean study, O(3) additions were constant or proportional and the amount of solar radiation interrupted by the canopy was used as a measure of growth; yield was not affected by the means of adding O(3); radiation interpreted over the growing season correlated well with plant growth dynamics. The cotton study also used four chronic doses of SO(2) and had a single replication where frusta were added to the chambers to control ingress of ambient pollutants; no interactions were found and only the highest SO(2) concentration caused a yield reduction in cotton; the addition of the frusta did not affect cotton sensitivity to O(3).

Publications: 81/01 to 81/12

HECK, W.W., TAYLOR, O.C., ADAMS, R., BINGHAM, G., MILLER, J., PRESTON, E. and WEINSTEIN, L. 1982. Assessment of Crop Loss From Ozone. *J. Air Pollut. Contr. Assoc.* 32:353-361.

HEAGLE, A.S., LETCHWORTH, M.B. and MITCHELL, C. 1983. Injury and yield responses of peanuts to chronic doses of ozone in open-top chambers. *Phytopathology* 73:551-555.

HEAGLE, A.S., HECK, W.W., RAWLINGS, J.O. and PHILBECK, R.B. 1983. Effects of chronic doses of ozone and sulfur dioxide on injury and yield of soybeans in open-top field chambers. *Crop Sci.* 23:1984-1191.

HECK, W.W., ADAMS, R.M., CURE, W.W., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W., RAWLINGS, J.D. and TAYLOR, D.C. 1983. A reassessment of crop loss from ozone. Environ. Sci. and Tech. 17:573-580A.
 HECK, W.W., CURE, W.W., RAWLINGS, J.D., ZARAGOZA, L.U., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W. and TEMPLE, P.J. 1984. Assessing impacts of ozone on agricultural crops: I. Overview. JAPCA 34:729-735

20.007* CRIS0047266
FIELD STUDIES OF PLANT RESPONSES TO ELEVATED CARBON DIOXIDE LEVELS

THOMAS J F; ROGERS H H; Botany; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: 7009-20790-009-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 22 JUL 81 to 30 SEP 84

Objectives: Establish dose-response relationships between various elevated CO₂ levels and crop production as well as some key crop processes.

Approach: The general approach for this work will use a plant exposure system (with open top chambers) for the generation of large-scale CO₂ test atmospheres in the field. Selected economically important crops will be exposed within the system over the growing season. The system is both cost effective and mechanically reliable over long time periods. The system further provides an environment as identical to field conditions as possible, given the above constraints. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at seeding. Plants will be exposed to ambient CO₂ and variable other set concentrations throughout their life cycle.

Progress: 81/01 to 81/12. A field program was designed and tested in 1980 to expose crop plants under field conditions to elevated levels of CO₂ (above ambient). Soybean was used as the primary test species but sweet potato was included in the last year of the study. Plants were grown in pots for the first two years and in the soil (ground) under normal field practices the last two years. Open-top field Chambers, developed to study ambient pollution effects on crop growth, were used to control the CO₂ concentrations around the test plants. Conical tops (frusta) were used to reduce ingress of outside air and make better utilization of CO₂ gas. Plants were grown from seedlings (1 or 2 weeks) to maturity under the different CO₂ regimes. Soil moisture stress was a variable several years. Studies included effects on water relations (water use efficiency), photosynthesis and movement of photosynthate, stomatal function, growth analysis, anatomical changes, growth and yield of mature plants. Elevated CO₂ during soybean growth generally resulted in: increased node number, increased water use efficiency, decrease of whole plant N to dry matter ratio in pot-grown plants, increase in root nodule

mass, extra carbon fixed is partitioned to starch, increased plant weight more in water stressed than non-stressed plants, increased seed dry weight.

Publications: 81/01 to 81/12

ROGERS, H.H., BINGHAM, G.E., THOMAS, J.F., SMITH, J.M., ISRAEL, D.W. and SURANO, K.A. 1982. Effects of long term concentration on field grown crops and trees. In: "Global Dynamics of Biospheric Carbon." pp. 9-45. Department of Energy, O19.
 DAVIS, J.M., RIORDAN, A.U. and LAWSON, R.E. 1983. A wind tunnel study of the flow field within and around open-top chambers used for air pollution studies. Bound. Layer Meteorol. 25:193-214.
 ROGERS, H.H., HECK, W.W., and HEAGLE, A.S. 1983. A field technique for the study of plant responses to elevated carbon dioxide concentrations. J. Air Pollut. Contr. Assoc. 33:42-44.
 ROGERS, H.H., BINGHAM, G.E., CURE, J.D., SMITH, J.M. and SURANO, K.A. 1983. Responses of selected plant species to elevated CO₂ in the field. J. Environ. Qual. 12:569-574.
 ROGERS, H.H., THOMAS, J.F. and BINGHAM, G.E. 1983. Responses of agronomic and forest species to elevated atmospheric carbon dioxide. Science 220:428-429.

20.008* CRIS0047610
RESPONSE OF PLANTS TO MIXTURES OF SELECTED ATMOSPHERIC CONTAMINANTS

HUANG J; REINERT R A; Plant Pathology; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: 7013-20790-012-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 21 APR 82 to 30 SEP 84

Objectives: Develop a greenhouse exposure system for studying the effects of up to three gaseous contaminants in various combinations. Determine short and long-term effects of gas mixtures on plant growth and productivity in both greenhouse and field exposures.

Approach: Design a multiple chamber greenhouse exposure system for the study of pollutant mixtures. Determine ratios and combinations of gaseous pollutants that occur in ambient air. Design experiments to include the above mixtures and their multiple so as to develop response surfaces for various gas mixtures. Determine plant response to these mixtures. Plan selected studies to help determine the mechanism of plant response and resistance.

Progress: 82/04 to 84/09. Systems were developed for studying the effect of gaseous contaminants ozone (O₃), sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) on crop plants. These systems included: 1) a charcoal filtered air (CF) and non-filtered air (NF) greenhouse section, 2) 20 plant exposure chambers 4 ft dia. by 4 1/2 ft tall placed in a CF 30 x 40 greenhouse section and facilitated with a pollutant dispensing and monitoring system, and 3) 12 rotating tables place in a 20

x 40 ft CF greenhouse section for exposing plants to simulated rain at different pH levels. Numerous plant species were grown in both CF and NF greenhouse air and developed O(3) injury in the NF air but not in the CF air. Soybean, cv. Bragg, were grown and exposed to NO(2) (0.0, 0.1, or 0.2 ppm) and SO(2) (0.0, 0.2, and 0.3 ppm) singly and in combination. Plants were harvested after either 5 or 15 exposures. Leaf discs from trifoliolate leaves were sampled for ribulose biphosphate carboxylase (RuBPC) activity and protein concentration. After 15 exposures to SO(2) RuBPC enzyme activity increased and then decreased in a curvilinear manner in the younger leaf tissue and decreased in a linear manner in older leaf tissue. Stem and leaf dry weight was significantly reduced by SO(2) while root weight was significantly reduced by mixtures of SO(2) and NO(2). Experiments were initiated to study the uptake and metabolism of CO(2) in soybean leaves following exposure to SO(2) and NO(2), alone and in combination.

Publications: 82/04 to 84/09

- KLARER, C.I., REINERT, R.A. and HUANG, J.S. 1984. Effects of sulfur dioxide and nitrogen dioxide on vegetative growth of soybeans. *Phytopathology* 74:1104-1106.
- KLARER, C.I., HUANG, J.S. and REINERT, R.A. 1984. Changes in ribulose biphosphate carboxylase activity, protein concentration and vegetative growth of soybeans over time in response to sulfur dioxide and nitrogen dioxide.
- REINERT, R.A. 1984. Plant response to air pollutant mixtures. *Ann. Rev. Phytopath.* 22:421-422.
- KLARER, C.I. 1983. Effects of sulfur dioxide and nitrogen dioxide singly and in combination over time, on ribulose biphosphate carboxylase activity in vegetative growth of soybean. MS. degree, Department of Plant Pathology.

20.009* CRIS0079679
PRODUCTION OF BREEDER SEED OF CEREAL AND FORAGE CROPS

MOSS D N; Crop Science; Oregon State University, Corvallis, OREGON 97331.
Proj. No.: ORE00230 Project Type: STATE
Agency ID: SAES Period: 15 APR 79 to 01 JAN 99

Objectives: Provide a source of nuclear and breeders seed of cereals, grasses and legumes. OR.

Approach: The plant breeders will select heads and individual plants from the appropriate breeding lines. The heads and plants will be threshed and planted as individual rows or lines. The plantings will then be carefully rogued for off-types and the seed bulked at harvest time.

Progress: 84/01 to 84/12. The primary task under this project this year has been to analyze and summarize data from several years study on the effects of acid rain on field crops. Neither wheat nor potatoes showed any yield reduction when the crops were exposed to

simulated acid rain in the pH range 3.5 to 5.5. Maize was the only field grown crop which showed any effect of acid rain on yield. Maize had a suppressed yield at pH 4.0 in two of three years. The most extensive experiments on maize were done in 1982, and there was no effect on yield of any treatment in that year. We concluded that acid rain is not likely to be a significant problem for crop plant production, and the fertilizer elements (S and N) contained in the rain may enhance yields in poorly fertilized crops.

Publications: 84/01 to 84/12

MOSS, D.N. 1984. Photosynthesis, respiration, and photorespiration in higher plants. In *PHYSIOLOGICAL BASIS OF CROP GROWTH AND DEVELOPMENT*. American Society of Agronomy, Madison, WI.

20.010* CRIS0076369
SOIL FERTILITY, MANAGEMENT, AND PLANT NUTRITION FOR FORAGE AND HORTICULTURAL CROP PRODUCTION IN EAST TEXAS

HABY V A; Research & Extension Center; Texas A&M University, Overton, TEXAS 75684.
Proj. No.: TEX06320 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 83 to 30 JUN 88

Objectives: Determine the influence of varying levels of soil acidity on the availability of soil and applied fertilizer nutrients for roses and warm and cool season grasses and legumes. Evaluate the efficiency of applied N and that fixed by leguminous plants for small grains and warm season grass production. Evaluate the influence of K fertilizers on disease reduction in small grains and Coastal bermudagrass. Determine the soil fertility and fertilizer requirements of blueberries and peaches under East Texas conditions. Determine the effect of acid rain on East Texas soils and crops. Relate crop responses from various plant nutrient applications to the soil test level of those nutrients in order to improve the predictability of the soil test for fertilizer needs.

Approach: Field studies on bench mark soils of East Texas will be used to evaluate the responses of soils and crops to fertilizer nutrients and limestone. Greenhouse research will support the field studies. Soil and plant analyses in the laboratory will help evaluate field and greenhouse experiment responses. Data will be evaluated by appropriate statistical analyses.

Progress: 84/01 to 84/12. Ryegrass yield responses to limestone rates of 0, 672, and 3810 kg/ha were 3119, 5063, and 6020 kg/ha, respectively. Yields increased from 4120 to 5629 kg/ha as P rate increased from 0 to 240 kg/ha, respectively. Winter wheat grain yield increased from 1463 to 4016 kg/ha with N rate increments from 0 to 224 kg/ha, respectively, but yield differences due to the N sources ammonium nitrate, urea, and urea phosphate were negligible. Prior year growth of subterranean clover contributed the equivalent of 70 kg N/ha to the wheat. Winter wheat grain yields were

similar for KCl and $K(2)SO(4)$ potassium sources. Yield response to K rate increases was not statistically significant. A versatile, three-point hitch, tractor-mounted applicator was designed and constructed to dispense fluid fertilizers from containers pressurized by a tractor-mounted and powered pressure system. This applicator is used to evaluate dribble band spacings, methods of application, rates, and combinations of fluid fertilizers applied to Coastal bermudagrass. A severe summer drought restricted growth but grass yield from the three harvests was significantly increased from 11,500 to 15,928 kg/ha as N rate increased from 45 to 135 kg/ha at site one, and from 8064 to 10,080 at site two which is a less responsive soil. Banded urea-ammonium nitrate at spacings of 18, 36, 53, and 71 cm between bands, and method of application had no significant effect on grass yield. Nitrogen source comparisons yielded mixed results between both sites.

Publications: 84/01 to 84/12

- NELSON, L.R., HABY, V.A., BATEMAN, C. and KREJSA B. 1984. Accumulation of Al, Ca, Mg, Mn, K and P in annual ryegrass due to soil flooding. American Society of Agronomy Abstracts.
- BRANDT, J.E., HONS, F.M. and HABY, V.A. 1984. The effect of nitrogen management on the yield and nitrogen uptake efficiency of soft red winter wheat. American Society of Agronomy abstracts.
- HABY, V.A., DAVIS, J.V. and SMITH, K.L. 1984. A versatile fluid fertilizer applicator for field research. American Society of Agronomy Abstracts.

21.001* CRISO084091
EFFECTS OF SO(2) AND OZONE ON GROWTH, PRODUCTIVITY, PHYSIOLOGY AND BIOCHEMISTRY

LAUCHLI A W; TIMM H; YANG S F; Inter Departmental; University of California, Davis, CALIFORNIA 95616.
 Proj. No.: CA-D*-XXX-4108-H Project Type: HATCH
 Agency ID: CSRS Period: 12 MAY 81 to 30 SEP 86

Objectives: To determine the effects of SO(2) and ozone on several varieties of field crops and vegetable differing in resistance to these air pollutants, in terms of growth, productivity, mineral nutrient uptake and osmotic relations of the plants, biochemical studies on lipid metabolism and ethylene production as related to SO(2) sensitivity, and to investigate the interactions between SO(2) and ozone stress and salinity.

Approach: Exposure to the air pollutants will be done in an environment-controlled chamber. SO(2) and ozone will be applied singly or in combination, and also in combination with salt stress. Growth will be measured as germination, emergence, root growth, and by protein analysis. Effects on nutrition will be assessed by ion transport experiments using radiotracers and measurement of inorganic and organic solutes. Stomatal apertures will be monitored with a diffusion porometer. The biochemistry of SO(2) injury will be determined by measuring production of ethane and ethylene and by following oxidation of SO(2) by sulfite measuring production of ethane and ethylene and by following oxidation of SO(2) by sulfite oxidase.

Progress: 84/01 to 84/12. Low level effects of SO(2) on tomato, alfalfa and cucurbits were studied. Germination of seed and pollen was unaffected, but root growth of tomato seedlings was extremely retarded by SO(2). (-) Cucurbit roots were less SO(2) sensitive. Root growth appears SO(2) sensitive because of HSO(3) formation in the medium. Pollen tube growth of all tested species was inhibited by SO(2). Effects of low level ozone pollution on growth and yield of beans were studied in the field using open-top field chambers. Two chamber designs were tested. Two-blower chambers were more effective in maintaining temperatures similar to ambient in the presence of plants than were one-blower chambers. Photosynthetically active radiation (PAR) was reduced by 20% within the chambers compared to ambient. Ozone variability in the chambers was only slight. Data on physiological parameters, growth and yield of beans under low-level ozone fumigation are being analysed. Initial results showed that "Blue Lake" bean growth was inhibited by 5 hr. daily fumigations with 0.06-0.08 μ O(3). A comprehensive final report for Air Resources Board is in preparation.

Publications: 84/01 to 84/12
 TIMM, H. and BARNES, K. 1984. Pollen germination and tube growth responses to low level SO(2) exposure. Hort Science 19(3)72.

21.002 CRISO086886
GENETIC IMPROVEMENT OF COTTON YIELD, QUALITY, AND EFFICIENCY OF PRODUCTION

ROSIELLE A A; WENG V K; Botany & Plant Sciences; University of California, Riverside, CALIFORNIA 92521.
 Proj. No.: CA-R*-BPS-4193-H Project Type: HATCH
 Agency ID: CSRS Period: 01 MAR 82 to 30 SEP 83

Objectives: Improve and stabilize cotton yield and quality by plant breeding. Specifically, to develop germplasm with: Resistance to damage by pests, diseases, and environmental stress; with improved efficiency of production; and increased yield potential quality. Develop improved breeding procedures and techniques for use with cotton and other crops.

Approach: Seek variability for appropriate traits. Study their inheritance and heritability and methods to incorporate them into breeding populations. Develop improved germplasm. Study techniques for continued improvement where needed. Research resistance to pink bollworm, verticillium wilt, and air pollution damage; traits contributing to high yield and adaptation in narrow row culture.

Progress: 82/03 to 83/09. Pink bollworm resistance: Thirty cultivars, representing lines with purported resistance and common U.S. cultivars were screened for resistance in the field in 1982. Measurements of boll damage, earliness, and seed damage were made. The cultivar AET-5, which has been reported to be resistant in Arizona on the basis of seed damage, appeared to be no better than DPL-61 in terms of boll damage. Two okra leaf cultivars, ORS-13 and ORMAR showed resistance in terms of boll and seed damage, but other okra leaf cultivars were susceptible. Approximately 400 cultivars were screened for resistance to pink bollworm in the field in a separate single replicate experiment. Several lines with apparent reduced boll and seed damage were identified. Air pollution resistance: Approximately 400 cultivars were screened for resistance in the field at Riverside in 1982. California cultivars showed intermediate to mild symptoms. Highly susceptible cultivars included Glandless Acala, Lockett, SP-37, Pronto, Paymaster 266, and Tamcot CAMD-E. Verticillium wilt resistance: Forty-eight cultivars were screened for resistance in the field in 1982. Numerous lines with good resistance were detected. Genotypic correlations between disease scores in the greenhouse following stem inoculation, and those in the field, were not high ($r=0.37$). Discrimination between cultivars for resistance was much better in the field than in the greenhouse.

Publications: 82/03 to 83/09
 ROSIELLE, A.A. 1983. The effect of variation of genetic variance and correlation between mean and variance on the efficiency of bulk yield testing. Euphytica 32:49-56.
 RAMEY, T.B. and ROSIELLE, A.A. 1983. HASS cluster analysis: a new method of grouping genotypes or environments in plant breeding. Theor. Appl. Genet. 66: 131-133.

DEVEY, M.E. and ROSIELLE, A.A. 1983. The relationship between field and greenhouse ratings for resistance to Verticillium wilt on cotton. Agronomy Abstracts. 75th Ann. Mtg. Amer. Soc. Agron., Aug. 14-19, 1983, p. 61.

21.003 CRIS0002662
INFLUENCE OF AIR POLLUTANTS AND CHEMICAL ADDITIVES ON INJURY AND PLANT GROWTH

TAYLOR D C; Botany & Plant Sciences; University of California, Riverside, CALIFORNIA 92521.

Proj. No.: CA-R*-BPS-2156-H Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 88

Objectives: Measure yield and physiological response of cotton to combinations of stress imposed by drought and ozone air pollution.

Approach: Open-top field chambers will be used to control 4 doses of ozone and controlled drip irrigation will provide 3 levels of drought stress. O(3) dose will be proportional to ambient levels at Riverside.

Progress: 84/01 to 84/12. Work on this project was focused on 2 principal areas during the period 1/1/84 through 12/31/84. The principal effort was continuation of studies to develop ozone dose-response data for alfalfa, a major agricultural crop in California and the U.S. The alfalfa plots were established on the USDA Cotton Research Station, Shafter, CA, during the summer of 1983. Air pollutant treatments were initiated April 1984. The experimental block was divided into 2 levels of moisture stress. Greatest stress as produced by delaying irrigation to reduce soil moisture to a preselected level and by application of less water than in normally irrigated plots. Six ozone treatments were superimposed on the 2 irrigation blocks. Treatments were: 1) activated charcoal filtered air; 2) ambient air; 3) 1.3 x ambient O(3); 4) 1.6 x ambient O(3); 5) 2 x ambient O(3); and 6) ambient plots without field chambers. Preliminary data shows that both elevated ozone and increased drought stress suppressed yield and interaction of pollutant and moisture stress was indicated. This experiment will be continued through 1985. A second study at Riverside was designed to determine the effectiveness of 3 formulations of ascorbic acid (vitamin C) in protecting 3 vegetable crops from significant crop loss from ambient ozone. Two concentrations of each formulation was applied once each week and once every 2 weeks through the growing season.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

21.004* CRIS0066186
CROP AND ORNAMENTAL PLANT TOLERANCE TO SULFUR DIOXIDE AND OZONE AIR POLLUTANT EXPOSURE

BOOTH J A; Entomology & Plant Pathology; New Mexico State University, Las Cruces, NEW MEXICO 88003.

Proj. No.: NM-1-3-42220 Project Type: STATE
 Agency ID: SAES Period: 01 JUL 82 to 30 JUN 84

Objectives: Complete studies now in progress re. effects of SO(2) on pecan nut quality. Determine differences in susceptibility to ozone SO(2), and mixtures of the two among commercial cultivars of alfalfa, chile pepper, and cotton. Identify and isolate pollution tolerant individuals through selections from large populations of alfalfa representing many cultivars.

Approach: Pecan nut quality alterations resulting from exposure to 3.0 ppm-hrs of SO(2) will be determined by measurement of nut weight, volume, density, meat wt., meat protein and liquid quantity. Treatments will be made biweekly throughout the 1982 season. Large numbers of plants of cultivars of alfalfa, cotton and chile pepper will be exposed to SO(2), ozone, and mixtures of the two gases in order to identify those which show tolerance to one or both of the gases. Vegetative propagation of tolerant lines will be used to isolate promising germ plasm for use in genetic improvement programs. The technique of convert sulfit to sulfate. Vegetative propagation will be used to isolate promising germ plasm for use in improvement programs.

Progress: 84/01 to 84/06. On December 20, 1983 the greenhouse housing the SO(2) treatment facility, and all of the isolated selections of alfalfa which showed some degree of tolerance to SO(2) exposure, were lost in a fire. In the subsequent months, especially considering the high cost of replacement of the facility, the decision was made to terminate this project and change the research direction. Existing data which was complete enough for publication was assembled, and at this point in time it appears that two manuscripts having to do with SO(2) effects on pecan nut retention and quality will be submitted for journal publication. The alfalfa SO(2-) tolerance research had not progressed sufficiently for publishable data to be accumulated.

Publications: 84/01 to 84/06
 NO PUBLICATIONS REPORTED THIS PERIOD.

21.005* CRIS0097557
THE EFFECTS OF ATMOSPHERIC POLLUTANTS ON THE REPRODUCTION OF AGRICULTURAL CROPS

DUBAY D; STUCKY J; NEAGLE A; Botany; N Carolina State University, Raleigh, NORTH CAROLINA 27650.

Proj. No.: NC09340 Project Type: CRGO
 Agency ID: CRGO Period: 01 SEP 85 to 30 SEP 87

Objectives: Proj 8501684. Determine the direct effects of simulated acid reproduction of corn, soybean, wheat, cotton, snap bean, and tomato,

determine the influence of chronic O(3) exposure on the effects of acid rain on cotton and soybean reproduction. Determine the effects of acid rain on the viability and fitness of seeds produced by treated flowers.

Approach: Flowers are exposed once to simulated rain of different acidities. Cotton and soybean are grown before and after rain treatment in chambers with charcoal-filtered air or air with added O(3). Treated flowers are scored for seed production, and seeds are tested for viability and fitness.

CM 23 SOYBEANS

23.001* CRIS0089156
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATER, AND
MATERIALS**

WALKER J T; Plant Pathology; Georgia Agric
Expt Station, Experiment, **GEORGIA** 30212.
Proj. No.: GE001341 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish, the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings and other materials in machinery or structure.

Approach: The Georgia collection site has been operational since October, 1978, and will continue as part of the NADP program. Data obtained is available to all interested scientists. Efforts research on agricultural and horticultural crops will encompass general growth responses including biomass and yield from simulated rain treatments and symptomology. Influence of simulants on endemic pathogens of commercial crops will be determined in growth chambers and field plots. Cooperative studies with scientists in other departments and agencies will be initiated.

Progress: 84/01 to 84/12. The 1983 quarterly volume weighted average pH of rain falling at the Georgia NADP/NTN site was 4.37, 4.71, 4.57 and 4.50. The six month average for 1984 is 4.50. The 1983 rainfall was 112.35 cm; for the first six months of 1984 it is 49.75 cm. Sulfate and nitrate remain the principle rainfall constituents, with deposition rates in 1984 comparable to those in 1983; six month sulfate rates were 878.6 and 823.3, respectfully. Nitrate (NO₃) rates were 467.7 and 453.2. Total suspended particulates (ug TSP/M-3) averaged 23.7 for 1983, and 35.8 for nine months of 1984. Lead levels assayed on hi-vol filters remain low (0.03 mg/m³). Daily O₃ concentrations averaged 2.86 for May through October. A portable rain simulator, using Bete Simulated Rain Nozzles and PVC pipe, was constructed. Trials revealed that the 2.5 cm pipe with pumping system at 5 or 10 psi delivered 2.1 gals per minute to adequately wet soybean foliage. This deposition rate approximates 0.64 cm/h. To evaluate the system, Davis soybeans were planted on June 18 in a field previously fertilized with 2173 kg. of 5-10-15 per hectare. Lasso was applied after planting and the field irrigated on June 19 to enhance germination. Simulated rain (pH 3.5) was applied to soybeans in each of three 2.4m x 2.4m plots at 2 rates, 208 or 416 liters, on four dates from August 21 to September 28. Plants in each plot were counted and bean yield determined at maturity. No visible injury was detected on soybean foliage.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

23.002 CRIS0096973
**DIFFERENTIAL CULTIVAR RESPONSE TO ACIDIC
PRECIPITATION**

BANWART W; Agronomy; University of Illinois,
Urbana, **ILLINOIS** 61801.
Proj. No.: ILLU-15-0508 Project Type: CRGO
Agency ID: CRGO Period: 01 SEP 85 to 31 AUG 87

Objectives: Proj 8501671. To identify the importance of differential cultivar response as one of the key interactive effects in soybean response to acidic precipitation. To identify the parameters that are associated with changes in harvested grain yields. To examine the relationship between visible leaf damage and flavonoid levels in soybean leaves of selected cultivars. To evaluate changes in chlorophyll, protein, and amino acids from active pod fill through senescence in selected cultivars.

Approach: Soybeans are planted in plots in a permanent (nonmoveable) rain exclusion shelter. The plot size for the study described is 3.0 m X 5.5 m, with 30 total plots. Each plot contains 8 single harvest rows of soybeans and two border rows. Soybeans are planted in rows with a 0.51 m spacing. The final stand is achieved by overplanting and thinning to a desired population of 320,000 plants/hectare following emergence. Twenty cultivars were chosen for this study to allow for the maximum possible expression of the differential cultivar response. Simulated rain is applied to the plots in this study by use of spray nozzles supported above the crop. Spray nozzles are raised as needed to insure a uniform rain distribution pattern. The amount of simulated rain applied and the application rate are monitored during each rain event by electronic flow meter-accumulators (Signet Scientific).

23.003* CRIS0097371
**A FIELD OF STUDY OF DRY DEPOSITION OF AIRBORNE
MATERIALS TO SOYBEAN AND CORN**

DOLSKE D A; Atmospheric Chemistry Section;
University of Illinois, Champaign, **ILLINOIS**
61820.
Proj. No.: ILLR-8501666 Project Type: CRGO
Agency ID: CRGO Period: 01 SEP 85 to 31 AUG 86

Objectives: PROJECT 8501666. The primary objective of this project is to routinely measure the dry deposition of sulfur and nitrogen - containing air pollutants to soybeans and corn. This information will be used to examine the interaction of dry- and wet-deposited materials on the plant surface.

Approach: Foliar surface sampling techniques are developed to provide a method for precisely and routinely determining the amount of dry deposition received by crop systems during the growing season. The methods will be used in a

coordinated program of surface sampling, throughfall collection and event-basis precipitation sampling--in both ambient rain and using simulated rain at pH's below and above ambient values.

23.004* CRISO092338
EFFECTS OF SIMULATED ACID PRECIPITATION
CONDITIONS ON ROOT NODULATION IN SOYBEAN AND
ALFALFA

KAUL K; Community Research Service; Kentucky State University, Frankfort, KENTUCKY 40601.
 Proj. No.: KY.X-10-84-01P Project Type: 1890/T
 Agency ID: CSRS Period: 10 FEB 84 to 09 FEB 88

Objectives: Study of growth of *R. japonicum* and *R. meliloti* strains isolated from Kentucky soils and certain other commercially available strains under high S, N, Al, and Fe and low Ca, K, Mo, and P. Assessment of the ability of the above mentioned bacterial strains to nodulate their host plants in laboratory and greenhouse under the above mentioned nutritional conditions. Assessment of the ability of nodules formed under simulated acid deposition conditions to fix atmospheric nitrogen. Assessment of the effects of simulated acid deposition conditions on soybean and alfalfa and recommendations regarding the best suited varieties of these crop plants and strains of *Rhizobium*.

Approach: Experiments will be done to determine the effects of acid rain on bacterial nodulation in roots of soybean and alfalfa. Effects of certain simulated acid rain conditions will be determined on root nodulating bacteria, the process of nodulation, and the ability of nodules to fix atmospheric nitrogen.

Progress: 84/02 to 84/12. Four strains of *Rhizobium japonicum* and four strains of *Rhizobium meliloti* were obtained from Nitrogen Fixation Laboratory of U.S. Department of Agriculture. In addition cultures of *Rhizobium* were isolated from root nodules of Essex and Cumberland varieties of soybean and Apalo variety of alfalfa from fields in central Kentucky. All of the above cultures are being maintained on yeast extract/mannitol medium. Purchase of all major pieces of equipment necessary for the research in this project has been completed. A co-investigator has been selected and he will be starting work on February 1, 1985.

Publications: 84/02 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

23.005* CRISO074252
REDUCING THE INFLUENCE OF AIR POLLUTION ON
PLANT PRODUCTIVITY IN THE NORTHEAST

MULCHI C L; AYCOCK M K JR; KENWORTHY W J;
 Agronomy; University of Maryland, College Park,
 MARYLAND 20742.
 Proj. No.: MD-B-127 Project Type: HATCH

Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Determine physiological, biochemical and morphological mechanisms of susceptibility and resistance of plant cultivars to air pollutants, and determine whether these are affected by interactions with biotic factors in the environment. Identify the genetic mechanisms of resistance of plant cultivars to air pollutants. Develop air pollutant resistant plant material.

Approach: Examine the photosynthetic and respiratory processes of resistant and susceptible cultivars of tobacco, soybean and wheat. Survey isoenzymes produced by resistant and susceptible lines using electrophoretic profiles to aid in locating potential genetic markers. Isolate and incorporate resistant genetic material in the plant breeding program.

Progress: 77/10 to 83/09. Over the life of B-127, research was focused on the following four areas: Examining the activity of peroxidase as a gene marker for ozone tolerance in tobacco; examining the effects of ozone on wheat cultivars grown in Maryland; the impact of ozone on the growth dynamics of tobacco, and investigating the effects of O(3) and SO(2) on nitrogen fixation and yields of soybean cultivars. The following conclusions may be drawn from the investigators: Peroxidase activity showed significant stimulations following exposure to ozone both in greenhouse and field studies; however, the magnitude of stimulation was variable across environments which suggest that it is too variable for use as a pollution tolerance screening device. Yields and grain quality were reduced in wheats exposed during flowering or throughout the growth of the plants. Significant differences were found among cultivars grown in Maryland. This research is being continued. Ozone was observed to significantly reduce the relative growth rates in four cultivars which differed significantly in visual responses. Therefore, ozone tolerance ratings should consider growth in addition to visual leaf injury in breeding programs. Total nodule activity in soybeans was reduced following exposures to O(3) and SO(2). Also, grain yields were significantly reduced in field studies following pollution treatments at two growth stages.

Publications: 77/10 to 83/09
 NO PUBLICATIONS REPORTED THIS PERIOD.

23.006 CRISO083103
EVALUATION OF SOYBEAN GERMLASM FOR STRESS
TOLERANCE AND BIOLOGICAL EFFICIENCY

DADSON R B; GUPTA G; Soybean Research Institute; University of Maryland Eastern Shore, Princess Ann, MARYLAND 21853.
 Proj. No.: MD.X-SOY-0011 Project Type: 1890/T
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 86

Objectives: To evaluate soybean germplasm for tolerance toward O3, NO2, SO2, Ph and Hg.

Approach: Soybean germplasm of MG III-VI will be screened for tolerance to high levels of o_3 , no_2 , so_2 , Pb, and Hg in open-air fumigation system in soybean field plots, greenhouse and controlled environmental growth cabinets. Approximately 250 lines of each maturity group will be screened. Rates of release of o_3 , no_2 , so_2 , Pb and Hg will be established and used in field evaluations during the growth seasons. Protein, oil and biochemical analysis will be carried out in winters.20.

Progress: 83/10 to 84/09. Evaluation of Soybean Germplasm for Stress Tolerance and Biological Efficiency 'Air Pollution - Crop Damage' laboratory facilities have been set up. Equipment to monitor the concentration of gaseous air pollutants (o_3 , SO_2 and NO_2 and CO_2), data acquisition and logging center, and photosynthesis systems are now in place. Preliminary experiments are under way to determine the best approach. Facilities to duplicate these studies in the field, using open top chambers, are being ordered. Evaluation of Soybean Germplasm for Biological Efficiency (Seed Yield Efficiency-SYE) Approximately 200 PIs from each of MG III, IV and V were evaluated for SYE. Dates from planting to reach R(1) through R(7) and plant height were recorded during the reproductive phase of growth. Between R(7) and R(8) four plants were harvested from each replication, oven dried and the seed and straw portions separated from each other. Weights of seeds and straw were recorded and the SYE calculated. A wide range of SYE was found in each maturity group. The ranges were MG III from 0.43 to 1.39, MG IV from 0.44 to 1.27, and in MG V from 0.27 to 1.56. Several PIs have SYE higher than the standard cultivar for the group. Later maturing PIs had the highest percent entries with SYE greater than 1. It is evident that ample variability exists for successful selection of parents with high SYE which will be useful in developing high yielding lines in breeding programs. An expanded report on this aspect of work is attached.

Publications: 83/10 to 84/09

DAOSON, R.B. JOSHI, J. and MURPHY, L. 1984.

Evaluation of soybean germplasm for biological efficiency - Harvest Index. In evaluation of soybean germplasm for stress tolerance and biological efficiency. 1890 Regional Research Project.

WELLS, P., 1984. Seed yield efficiency in soybean germplasm. World Soybean Conference III - Ames, Iowa. August, 1984.

23.007* CRIS0082896
SULFUR DIOXIDE AND ACID RAIN: COMPARATIVE UPTAKE AND NEUTRALIZATION OF SULFUR POLLUTION BY PLANTS

CRAKER L E; Plant & Soil Sciences; University of Massachusetts, Amherst, MASSACHUSETTS 01003.

Proj. No.: MAS00499 Project Type: HATCH
 Agency ID: CSRS Period: 01 NOV 80 to 30 SEP 86

Objectives: Examine and quantify the effectiveness of plants in the uptake and neutralization of sulfur pollution. Compare the two major forms of atmospheric sulfur pollution (SO_2) and acidic rain) for their relative hazard to the plants.

Approach: The individual and collective response(s) of plants will be examined following exposure to sulfur pollution as SO_2 or sulfuric acid rain. Initial studies are selectively short term and designed to determine the contribution of plants to the absorption and neutralization of SO_2 and acid rain plus evaluate the acute injury to plants caused by SO_2 and acid rain. Longer term studies will be used to investigate the cumulative response of model plant populations to SO_2 and to simulated acid rain.

Progress: 83/10 to 84/09. The susceptibility of plants to sulfur containing acid rain, sulfur dioxide, and combinations of acid rain and sulfur dioxide have been evaluated. Simulated pollution episodes have been studied with corn, Zea mays. Uptake and absorption of sulfur into plant tissue is greatest under high sulfur dioxide concentrations and low pH acid rains. More sulfur is absorbed from sulfur dioxide than from sulfur containing acid rain when both have equivalent amounts of sulfur. Sulfur containing acid rain may inhibit pollenization and fertilization of corn in the field. An evaluation of acid neutralizing powers of crop leaf tissue demonstrated significant differences among plants. Red Kidney beans and wheat leaves had the greatest buffering capacity.

Publications: 83/10 to 84/09

CRAKER, L.E. and BERNSTEIN, O. 1984.

Buffering of acid rain by leaf tissue of selected crop plants. Env. Pollut. (in press).

SIMON, J.E. 1984. Comparative uptake of sulfur in sulfur dioxide and acid rain by corn. Ph.D. Thesis, Univ. of Massachusetts.

23.008 CRIS0012208
PHYSIOLOGICAL AND BIOCHEMICAL RESPONSE OF VEGETATION TO AIR POLLUTANTS

BRENNAN E; LEONE I A; Plant Pathology; Rutgers University, New Brunswick, NEW JERSEY 08903.
 Proj. No.: NJ11151 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 88

Objectives: Determine if an antioxidant treatment (ethylenediurea), applied to soybean plants has the potential to overcome yield losses due to ozone pollution. Determine the effect of antioxidant on the physiology/biochemistry of the soybean plant, especially those parameters known to be related to ozone response.

Approach: Two soybean cultivars, one tolerant and the other susceptible to ozone on the basis of foliar tests will be selected for the study. Plants will be grown in open-top modules with or without a charcoal-filtered ambient air supply. They will be drenched with a solution

of antioxidant biweekly or left untreated. Extra ozone exposures will be applied to some of the plants to insure sufficiently high pollution to reduce seed yield. Seed yield will be measured at maturity for all treatment groups. Plants will be grown in a greenhouse with a charcoal filtered air supply to remove ambient ozone. They will be drenched with a solution of antioxidant biweekly or left untreated. Three experiments are anticipated (a) measurement of biomass over time.

Progress: 84/01 to 84/12. Greenhouse and field experiments were conducted to evaluate the impact of ozone pollution on chlorophyll content and nitrogen metabolism of Cutler 71 soybean inoculated with *Rhizobium japonicum* and planted in perlite:vermiculite:sand medium. Every other day, all pots received 500 ml of a N-free solution and on alternate days, either 500 ml of 10 mM KNO₃ (+N plants) or 500 ml of distilled water (-N plants). At V5, R1, R3, R5 and R6, + and -N plants were exposed to a 12 hour ozone fumigation ranging from 0.02 ppm at 0800 hr, peaking at 0.20 ppm at 1500 hr and then decreasing again to 0.02 ppm at 2000 hr. Generally, ozone decreased leaf chlorophyll and nitrogen and temporarily inhibited nitrate reductase activity in the leaves (in vivo assay). Root nodule nitrogenase activity (C(2)H(2) reduction) was not affected by ozone except at R3 in +N plants when a significant decrease was noted in treated plants. In the field, cv. Corsoy, Williams, and Cutler 71 were planted in replicated plots using standard agronomic techniques. The antioxidant, EDU, was applied as a soil drench (500 ppm) to half of the plots to provide ozone-free control plants. Four times during the growing season at V8, R1.5, R3.5, and R5.5, leaf and root assays were performed on + and -EDU plants. EDU reduced the amount of visible injury on all cultivars, increased leaf chlorophyll in Cutler 71 and Williams but not Corsoy, and had no effect on leaf nitrate reductase activity.

Publications: 84/01 to 84/12

- ELLIOTT, C., REBBECK, J. and BRENNAN, E. 1984. The effect of ambient rainfall (pH 3.8) on Saranac alfalfa grown in New Jersey. The Bull. N.J. Acad. of Sci. Vol. 29:40.
- REBBECK, J. and BRENNAN, E. 1984. The effect of simulated acid rain and ozone on the yield and quality of glasshouse-grown alfalfa. Environ. Pollut. 36:7-16.
- SMITH, G. and BRENNAN, E. 1984. The physiological response of soybean to ozone fumigation at various growth stages. Phytopathology Vol. 74, No. 7:843. (Abstract.).

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors. To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: Field grown potatoes and soybeans will be treated with antioxidant (EDU) at specified growth stages and foliar injury and crop yields related to those of untreated plants and to the prevailing ozone dosages. Test trees will be exposed to saline spray under controlled land ambient conditions and relationships determined between Na⁺ or Cl⁻ uptake and epicuticular wax quantity and quality. Tree and crop species will be screened through EDU and open-top field chamber techniques to identify resistant cultivars.

Progress: 84/01 to 84/12. An on-going field experiment to assess the impact of oxidant pollution on Williams and Cutler soybean cultivars through the use of the anti-oxidant IDU was repeated in 1984. IDU treatments were made weekly. Although the data have not yet been analyzed statistically, there appear to be no differences between yields in IDU-treated and untreated plots. Five other soybean cultivars: Beeson, Asgrow 3127, MS250, Della, Century, and Elf were also included in the test to compare their foliar symptoms and yields with Williams and Cutler. Conditions were generally more favorable for soybean production in 1984 than in either of the 2 previous years. Five replicates of 3-year-old seedlings of *Pinus thunbergii* and *Pinus strobus* were grown at ambient conditions and at three temperature (10C, 21C, 32C) and photoperiod (8h, 12h, 16h) regimes. Foliar epicuticular waxes were extracted and analyzed for alkane content using temperature-programmed gas chromatography. Foliar epicuticular wax from the salt-tolerant *Pinus thunbergii* seedling had significantly more alkanes than did the wax from the salt-sensitive *Pinus strobus* seedlings. The alkane content increased in both species as the temperature and photoperiod were increased. Greater alkane concentrations in the waxes of the tolerant *Pinus thunbergii* and in the waxes of both species at the higher temperatures and photoperiods make the waxes less permeable to polar solution.

Publications: 84/01 to 84/12

- CLARKE, B.B., BRENNAN, E., and REBBECK, J. 1984. EDU: A tool for assessing crop loss due to ambient oxidants. Phytopathology (Abstr) 74:843.
- SIMINI, M. and LEONE, I.A. 1984. The role of foliar epicuticular waxes in the tolerance of pines to de-icing salt spray. Phytopathology (Abstr) 74:842.

23.009* CRIS0074268
REDUCING THE INFLUENCE OF AIR POLLUTION ON
PLANT PRODUCTIVITY

LEONE I A; BRENNAN E; Plant Pathology; Rutgers University, New Brunswick, NEW JERSEY 08903.
Proj. No.: NJ11250 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

23.010* CRIS0097557
**THE EFFECTS OF ATMOSPHERIC POLLUTANTS ON THE
 REPRODUCTION OF AGRICULTURAL CROPS**

DUBAY D; STUCKY J; NEAGLE A; Botany; N
 Carolina State University, Raleigh, **NORTH
 CAROLINA** 27650.
 Proj. No.: NC09340 Project Type: CRGO
 Agency ID: CRGO Period: 01 SEP 85 to 30 SEP 87

Objectives: Proj 8501684. Determine the direct effects of simulated acid reproduction of corn, soybean, wheat, cotton, snap bean, and tomato, determine the influence of chronic O(3) exposure on the effects of acid rain on cotton and soybean reproduction. Determine the effects of acid rain on the viability and fitness of seeds produced by treated flowers.

Approach: Flowers are exposed once to simulated rain of different acidities. Cotton and soybean are grown before and after rain treatment in chambers with charcoal-filtered air or air with added O(3). Treated flowers are scored for seed production, and seeds are tested for viability and fitness.

23.011* CRIS0046127
**LOSS OF CROP PRODUCTION BY OZONE, SULFUR
 DIOXIDE, NITROGEN DIOXIDE AND OTHER MIXTURES**

MIKSCH J P; HECK W W; Botany; N Carolina
 State University, Raleigh, **NORTH CAROLINA**
 27650.
 Proj. No.: 7005-20790-008-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 01 APR 80 to 30 SEP 83

Objectives: Develop a National crop loss assessment program to determine the loss of crop production by ozone, sulfur dioxide, nitrogen dioxide and their mixtures.

Approach: Determine dose-response curves for selected important economic crops (i.e. soybean, corn, wheat, oats, forages) from exposure to ambient air pollutants under field conditions. Experimental designs will utilize open-top field chambers over small field plots. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at 2 weeks from seeding. Plants will be exposed to background ozone, ambient ozone and three or four higher ozone increments for 7 hrs/day over the summer. Ozone increases will be set amounts over ambient so normal daily fluctuations will be observed. Similar designs will be used for sulfur dioxide, nitrogen dioxide and gas mixtures.

Progress: 81/01 to 81/12. Peanut ('NC-6'), soybean ('Davis', 2 designs) and cotton ('Stoneville 213') were exposed to 4 to 5 different chronic doses of ozone (O(3)) in open-top field chambers from seedling to harvest. Data were analyzed using linear regression and several three-parameter models were tested; the Weibull function was considered the best. Estimates of yield

reductions at ambient concentrations of O(3) (0.05 to 0.06 ppm for a 7-hr/day seasonal mean) were: peanut - 12 to 19%, soybean - 5 to 24% and cotton - 10 to 16%. A zonal air pollution system was developed, tested and used in the exposure of field grown peanuts. The first soybean study also used four chronic doses of sulfur dioxide (SO(2)); no interactions were found and, except at the highest concentration used, no SO(2) effects were reported. In the second soybean study, O(3) additions were constant or proportional and the amount of solar radiation interrupted by the canopy was used as a measure of growth; yield was not affected by the means of adding O(3); radiation interpreted over the growing season correlated well with plant growth dynamics. The cotton study also used four chronic doses of SO(2) and had a single replication where frusta were added to the chambers to control ingress of ambient pollutants; no interactions were found and only the highest SO(2) concentration caused a yield reduction in cotton; the addition of the frusta did not affect cotton sensitivity to O(3).

Publications: 81/01 to 81/12

- HECK, W.W., TAYLOR, O.C., ADAMS, R., BINGHAM, G., MILLER, J., PRESTON, E. and WEINSTEIN, L. 1982. Assessment of Crop Loss From Ozone. J. Air Pollut. Contr. Assoc. 32:353-361.
 HEAGLE, A.S., LETCHWORTH, M.B. and MITCHELL, C. 1983. Injury and yield responses of peanuts to chronic doses of ozone in open-top chambers. Phytopathology 73:551-555.
 HEAGLE, A.S., HECK, W.W., RAWLINGS, J.O. and PHILBECK, R.B. 1983. Effects of chronic doses of ozone and sulfur dioxide on injury and yield of soybeans in open-top field chambers. Crop Sci. 23:1984-1191.
 HECK, W.W., ADAMS, R.M., CURE, W.W., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W., RAWLINGS, J.O. and TAYLOR, O.C. 1983. A reassessment of crop loss from ozone. Environ. Sci. and Tech. 17:573-580A.
 HECK, W.W., CURE, W.W., RAWLINGS, J.O., ZARAGOZA, L.J., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W. and TEMPLE, P.J. 1984. Assessing impacts of ozone on agricultural crops: I. Overview. JAPCA 34:729-735

23.012* CRIS0047266
**FIELD STUDIES OF PLANT RESPONSES TO ELEVATED
 CARBON DIOXIDE LEVELS**

THOMAS J F; ROGERS H H; Botany; N Carolina
 State University, Raleigh, **NORTH CAROLINA**
 27650.
 Proj. No.: 7009-20790-009-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 22 JUL 81 to 30 SEP 84

Objectives: Establish dose-response relationships between various elevated CO(2) levels and crop production as well as some key crop processes.

Approach: The general approach for this work will use a plant exposure system (with open top chambers) for the generation of large-scale CO₂ test atmospheres in the field. Selected economically important crops will be exposed within the system over the growing season. The system is both cost effective and mechanically reliable over long time periods. The system further provides an environment as identical to field conditions as possible, given the above constraints. Crops will be planted using acceptable field techniques. Plots will be identified and chambers placed over the plots at seeding. Plants will be exposed to ambient CO₂ and variable other set concentrations throughout their life cycle.

Progress: 81/01 to 81/12. A field program was designed and tested in 1980 to expose crop plants under field conditions to elevated levels of CO₂ (above ambient). Soybean was used as the primary test species but sweet potato was included in the last year of the study. Plants were grown in pots for the first two years and in the soil (ground) under normal field practices the last two years. Open-top field Chambers, developed to study ambient pollution effects on crop growth, were used to control the CO₂ concentrations around the test plants. Conical tops (frusta) were used to reduce ingress of outside air and make better utilization of CO₂ gas. Plants were grown from seedlings (1 or 2 weeks) to maturity under the different CO₂ regimes. Soil moisture stress was a variable several years. Studies included effects on water relations (water use efficiency), photosynthesis and movement of photosynthate, stomatal function, growth analysis, anatomical changes, growth and yield of mature plants. Elevated CO₂ during soybean growth generally resulted in: increased node number, increased water use efficiency, decrease of whole plant N to dry matter ratio in pot-grown plants, increase in root nodule mass, extra carbon fixed is partitioned to starch, increased plant weight more in water stressed than non-stressed plants, increased seed dry weight.

Publications: 81/01 to 81/12

- ROGERS, H.H., BINGHAM, G.E., THOMAS, J.F., SMITH, J.M., ISRAEL, D.W. and SURANO, K.A. 1982. Effects of long term concentration on field grown crops and trees. In: "Global Dynamics of Biospheric Carbon." pp. 9-45. Department of Energy, O19.
- DAVIS, J.M., RIORDAN, A.J. and LAWSON, R.E. 1983. A wind tunnel study of the flow field within and around open-top chambers used for air pollution studies. *Bound. Layer Meteorol.* 25:193-214.
- ROGERS, H.H., HECK, W.W., and HEAGLE, A.S. 1983. A field technique for the study of plant responses to elevated carbon dioxide concentrations. *J. Air Pollut. Contr. Assoc.* 33:42-44.
- ROGERS, H.H., BINGHAM, G.E., CURE, J.D., SMITH, J.M. and SURANO, K.A. 1983. Responses of selected plant species to elevated CO₂ in the field. *J. Environ. Qual.* 12:569-574.
- ROGERS, H.H., THOMAS, J.F. and BINGHAM, G.E. 1983. Responses of agronomic and forest species to elevated atmospheric carbon

dioxide. *Science* 220:428-429.

23.013 CRIS0085187 RECOGNITION MECHANISMS, NITROGEN FIXATION AND PHOTOSYNTHESIS IN SOYBEAN-PARASITE INTERACTIONS

HUANG J; Plant Pathology; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
Proj. No.: NC03767 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Characterize the recognition mechanism(s) in host-parasite interactions; determine the effect of soybean cyst nematode on recognition mechanisms in the soybean-Rhizobium system; elucidate the effect of soybean cyst nematode on biochemistry of symbiotic nitrogen fixation; determine the effect of air pollutants on photosynthesis.

Approach: Determine the recognition mechanisms in host-parasite interactions using soybean tissue culture as a model system; determine the effect of system; determine the effect of soybean cyst nematode on the binding of rhizobia to soybean root hairs; determine the biochemical changes in cyst nematode-infected soybean; determine the effect of air pollutants on photosynthetic carbon fixation, photophosphorylation and ribulose-1,5-bisphosphate carboxylase activity in soybean.

Progress: 84/01 to 84/12. Structural changes in developing soybean nodules as affected by *Heterodera glycines* were investigated by light and electron microscopy. The most conspicuous features in the infected plants were the massive accumulation of starch granules and crystalline arrays of phytoferritin in the plastids of cells in the nodular central tissues. Although small starch granules occasionally occurred in similar tissues of control plants, phytoferritin was not observed. The observations suggest that metabolism of carbohydrates and iron-containing compounds is affected by the presence of the cyst nematode. Multiplication of strains of *Xanthomonas campestris* pv. *oryzae* on rice cultivars and penetration of the bacteria through water pores of leaf blades also were investigated with scanning electron microscopy. Bacteria of strain PX061, which is virulent to cultivars TN1 and CAS 209, multiplied immediately outside the water pores and some bacteria had gained entrance through these pores. Cells of PX0101, a strain that has lost its virulence, did not multiply significantly on the leaf surface and appeared to be embedded in a thin layer of exudate secreted by the water pores. These results suggest that bacteria are immobilized and inhibited from dividing by excretions from water pores in incompatible host-bacteria combinations.

Publications: 84/01 to 84/12

- HUANG, J.S., BARKER, K.R., and VAN DYKE, C.G. 1984. Suppression of binding between rhizobia and soybean roots by *Heterodera glycines*. *Phytopathology* 74:1381-1384.

- KO, M.P., BARKER, K.R., and HUANG, J.S. 1984. Nodulation of soybeans as affected by half-root infection with *Heterodera glycines*. *J. of Nematol.* 16:97-105.
- MEW, T.W., MEW, I-P. C., and HUANG, J.S. 1984. Scanning electron microscopy of virulent and avirulent strains of *Xanthomonas campestris* pv. *oryzae* on rice leaves. *Phytopathology* 74:635-641.
- KLARER, C.I., REINERT, R.A., and HUANG, J.S. 1984. Effects of sulfur dioxide and nitrogen dioxide on vegetative growth of soybeans. *Phytopathology* 74:1104-1106.
- ATKINSON, M.M. 1984. Biochemistry and physiology of host-parasite interaction in tissue culture system. Ph.D. Thesis. North Carolina State University, Raleigh. 87 p.

23.014* CRIS0047610
RESPONSE OF PLANTS TO MIXTURES OF SELECTED ATMOSPHERIC CONTAMINANTS

HUANG J; REINERT R A; Plant Pathology; N Carolina State University, Raleigh, NORTH CAROLINA 27650.
 Proj. No.: 7013-20790-012-00S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 21 APR 82 to 30 SEP 84

Objectives: Develop a greenhouse exposure system for studying the effects of up to three gaseous contaminants in various combinations. Determine short and long-term effects of gas mixtures on plant growth and productivity in both greenhouse and field exposures.

Approach: Design a multiple chamber greenhouse exposure system for the study of pollutant mixtures. Determine ratios and combinations of gaseous pollutants that occur in ambient air. Design experiments to include the above mixtures and their multiple so as to develop response surfaces for various gas mixtures. Determine plant response to these mixtures. Plan selected studies to help determine the mechanism of plant response and resistance.

Progress: 82/04 to 84/09. Systems were developed for studying the effect of gaseous contaminants ozone (O₃), sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) on crop plants. These systems included: 1) a charcoal filtered air (CF) and non-filtered air (NF) greenhouse section, 2) 20 plant exposure chambers 4 ft dia. by 4 1/2 ft tall placed in a CF 30 x 40 greenhouse section and facilitated with a pollutant dispensing and monitoring system, and 3) 12 rotating tables placed in a 20 x 40 ft CF greenhouse section for exposing plants to simulated rain at different pH levels. Numerous plant species were grown in both CF and NF greenhouse air and developed O₃ injury in the NF air but not in the CF air. Soybean, cv. Bragg, were grown and exposed to NO₂ (0.0, 0.1, or 0.2 ppm) and SO₂ (0.0, 0.2, and 0.3 ppm) singly and in combination. Plants were harvested after either 5 or 15 exposures. Leaf discs from trifoliate leaves were sampled for ribulose biphosphate carboxylase (RuBPC) activity and protein concentration. After 15 exposures to SO₂ RuBPC enzyme activity increased and then

decreased in a curvilinear manner in the younger leaf tissue and decreased in a linear manner in older leaf tissue. Stem and leaf dry weight was significantly reduced by SO₂ while root weight was significantly reduced by mixtures of SO₂ and NO₂. Experiments were initiated to study the uptake and metabolism of CO₂ in soybean leaves following exposure to SO₂ and NO₂, alone and in combination.

- Publications:** 82/04 to 84/09 .
- KLARER, C.I., REINERT, R.A. and HUANG, J.S. 1984. Effects of sulfur dioxide and nitrogen dioxide on vegetative growth of soybeans. *Phytopathology* 74:1104-1106.
- KLARER, C.I., HUANG, J.S. and REINERT, R.A. 1984. Changes in ribulose biphosphate carboxylase activity, protein concentration and vegetative growth of soybeans over time in response to sulfur dioxide and nitrogen dioxide.
- REINERT, R.A. 1984. Plant response to air pollutant mixtures. *Ann. Rev. Phytopath.* 22:421-422.
- KLARER, C.I. 1983. Effects of sulfur dioxide and nitrogen dioxide singly and in combination over time, on ribulose biphosphate carboxylase activity in vegetative growth of soybean. MS. degree, Department of Plant Pathology.

23.015 CRIS0093300
GENETIC AND ENVIRONMENTAL FACTORS AFFECTING RESPONSE OF SOYBEANS TO ACID RAIN

ALLEN F L; LESSMAN G M; WOLT J D; Plant & Soil Sciences; University of Tennessee, Knoxville, TENNESSEE 37916.
 Proj. No.: TEN00737 Project Type: SPECIAL GRANT
 Agency ID: CSRS Period: 01 JUN 84 to 31 MAY 87

Objectives: Characterize acid rain effects on growth and yield of ancestral lines of U.S. soybean cultivars. Evaluate the importance of environmental conditions on level of damage to soybeans from acid rain. Determine if response to acid rain of cultivars can be predicted from response data of ancestral lines.

Approach: Twelve ancestral lines and a set of soybean cultivars which trace their origin to those lines will be subjected to three pH levels of simulated acid rain. Simulated rain will be applied via stationary simulators and via tractor-mounted sprayers for spray-to-wet applications. Data will be collected on percent foliar lesions, length of internodes, seed weight and yield, harvest index, foliar chlorophyll and nutrient content, and stomatal diffusive resistance. Data from ancestral lines and cultivars will be analyzed to make and test predicted responses to acid rain, respectively.

Progress: 84/06 to 84/12. A preliminary experiment was initiated to evaluate the relative sensitivities of 12 ancestral lines of soybeans to three levels of simulated acid rain (pH 3.2, 4.2, 5.2). The pH levels reflect the annual worst case, weighted average ambient, and control rainfall events, respectively. Replicated hill plots of the lines were planted in June under rainfall simulators at the Air

Pollution Effects Field Research Facility at the Oak Ridge National Laboratory. Due to equipment installation delays, simulated rain treatments were not started until 5 September. Rain treatments were subsequently applied twice weekly in rates equal to one-half the 30 year ambient average for the area (1.05 & 0.85 cm per application in September & October, respectively). Maturity group II and III lines were nearing physiological maturity when the simulated acid rain treatments were started; therefore, no data were obtained on the 5 early maturing lines involved in the experiment. The treatments were terminated on 29 October when the 7 group V IX lines were near physiological maturity. From the relatively short duration of treatments and of the 7 lines from which data were obtained, no measurable effects of the simulated acid rain on either soybean growth or seed yield were detected. The second and third years of the project will involve larger field plots with different soil types and soil management factors at two locations which might influence the response of genotypes to different acid rain levels.

Publications: 84/06 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

23.016* CRIS0074470
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

CHEVONE B I; MOORE L D; WINNER W E; Plant Pathology Physiology & Weed Science; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
Proj. No.: VA-622292 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield, and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors. To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: Fumigate field crops and forest tree species with ozone, sulfur dioxide and nitrogen dioxide singly and in various combinations with acidic rain. Measure symptoms, growth parameters, chlorophyll, carbohydrates and sulfur levels. Inoculate pollution stressed plants with *Phytophthora* or *Collectotrichum* and determine the rates of disease development and the disease severity. Measure changes in carbohydrate and lipid levels in leaves and roots and absolute changes in enzymes and compounds involved in photosynthesis. Screen bean, pine, ash and tobacco cultivars, lines and introductions for tolerance to acidic rain, ozone and sulfur dioxide. Screening includes field trials and fumigation tests.

Progress: 84/01 to 85/09. Soybeans were exposed to 0.20 ppm ozone and 0.70 ppm sulfur dioxide in various combinations. Fumigations were administered for 2 h either as a single pollutant (O₃ or SO₂), simultaneously (O₃ + SO₂) or in overlapping pollutant combinations. After 2 h exposure to O₃ or SO₂ the carbon

dioxide exchange rate (CER) was affected. Exposure to O₃ followed by O₃ + SO₂, SO₂ followed by SO₂ + O₂ and continuous O₃ + SO₂ significantly reduced CER. However, stomatal resistance was only altered by the simultaneous fumigation with O₃ + SO₂. These results suggest that SO₂ and O₃ affect different biochemical processes associated with CO₂ metabolisms. Plant species had patterns of visible foliar injury that reflected SO₂ - stress gradients near Hawaiian volcano vents. Injury reflected, in part, species differences in stomatal response to SO₂. The most seriously injured leaves do not close their stomata when exposed. The most SO₂ - resistant species were the most abundant indicating volcanic SO₂ may exert selective forces on community development. A general model of annual SO₂ absorption was calculated for both mosses and vascular plants to determine if differences in absorption could account for extreme SO₂ sensitivity known for mosses. Analysis of SO₂ absorption took into account seasons, precipitation, evergreen forests, deciduous forests, arctic tundras, and deserts. SO₂ absorption for mosses ranged from 30 to 400 fold higher for mosses than for vascular plants.

Publications: 84/01 to 85/09
CHEVONE, B. I. and YANG, Y. S., 1985, CO(2) exchange rates and stomatal diffusive resistance in soybeans exposed to O₂ and SO(2), Can. J. Plant Sci. 65:267-274.
WINNER, W. E. and MOONEY, H. A., 1985, Ecology of SO(2) resistance V. Effects of Volcanic SO(2) on Native Hawaiian Plants, Oecologia, 66:387-393.
WINNER, W. E. and ATKINSON, C. J., 1985, Annual Absorption of Gaseous Air Pollutants by Mosses and Vascular Plants in Divers Habitats, In: the Effects of Acid Deposition on Forests, Wetlands, and Agricultural Ecosystems. In Press.

26.001 CRIS0091203 BREEDING, TESTING AND QUALITY EVALUATIONS OF MARYLAND TOBACCO

AYCOCK M K JR; MCKEE C G; BRUNS H A; Agronomy;
University of Maryland, College Park, MARYLAND
20742.

Proj. No.: MD-B-141 Project Type: STATE
Agency ID: SAES Period: 01 OCT 83 to 30 SEP 86

Objectives: To develop new varieties of Maryland tobacco that are superior to the standard varieties in one or more agronomic and chemical traits. To create genetic variation; to determine the predominant type of genetic variability present in Maryland tobacco populations; to select desirable, high quality, disease, insect, and lodging resistant lines with high yield potential; and to continue to test and release superior varieties. To utilize haploid breeding procedures to develop doubled haploid lines for testing.

Approach: Genetic variability is continually being created by hybridization of the standard Maryland tobacco varieties and advanced breeding lines which contain one or more outstanding agronomic trait(s). Estimates of heterosis and types of genetic variances found within the Maryland tobacco population, suggest that breeding and selection procedures appropriate for the accumulation of desirable genes in a homozygous condition should be utilized. During the segregating generations, all genetic material is screened for resistance to a number of diseases, and evaluated for a number of agronomic, chemical and physical traits. To shorten the time needed to develop homozygous lines, haploid breeding procedures will be incorporated into the breeding program.

Progress: 84/01 to 84/12. Replicated Maryland tobacco variety trials were conducted at three locations to study the response of tobacco cultivars and breeding lines to different soil and climatic conditions. Several breeding lines compared very favorably with the standard cultivars for yield and quality, and in general had better disease resistance than the standards. Md. 609 was the most popular cultivar planted in 1984, accounting for 61% of the seed distributed. Seed distribution for Md. 872 and Md. 341 was 20 and 11%, respectively. Breeding for resistance to several diseases is still a major part of the program. In the field nursery 118 entries were screened for tobacco mosaic virus (TMV) and wildfire (*Pseudomonas tabaci*) resistance, and 93% of the entries were resistant to both diseases. In the greenhouse, 360 entries were screened for black shank (*Phytophthora parasitica* var. *Nicotianae*) resistance, and 37% of the entries had adequate levels of resistance.

Publications: 84/01 to 84/12

- DEVERNA, J.W. and AYCOCK, M.K., Jr. 1983. Hybridization among Maryland, burley, fire-cured, sun-cured, and flue-cured type tobaccos. 11. Heterosis and inbreeding. Tobacco Sci. 27:158-162.
- PETOLINO, J.F., MULCHI, C.L., and AYCOCK, M.K., Jr. 1983. Leaf injury and peroxidase activity in ozone-stressed tobacco cultivars and hybrids. Crop Sci.

23:1102-1106.

- AYCOCK, M.K., Jr. and MCKEE, C.G. 1985. Genetic variability, heterosis and combining ability estimates for root weights of Maryland tobacco. Crop Sci. 25: (in press).
- AYCOCK, M.K., Jr., SKODG, H.A., MENCHEY, E.K., MCKEE, C.G., and MULCHI, C.L. 1983. Performance of Maryland tobacco varieties and breeding lines, 1981 and 1982. Maryland Agric. Exp. Sta. MP 985.
- MENCHEY, E.K. 1984. Morphological characteristics associated with lodging of tobacco. M.S. Thesis. Univ. of Maryland, College Park. 137p.

26.002* CRIS0074252 REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY IN THE NORTHEAST

MULCHI C L; AYCOCK M K JR; KENWORTHY W J; Agronomy; University of Maryland, College Park, MARYLAND 20742.
Proj. No.: MD-B-127 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Determine physiological, biochemical and morphological mechanisms of susceptibility and resistance of plant cultivars to air pollutants, and determinewhether these are affected by interactions with biotic factors in the environment. Identify the genetic mechanisms of resistance of plant cultivars to air pollutants. Develop air pollutant resistant plant material.

Approach: Examine the photosynthetic and respiratory processes of resistant and susceptible cultivars of tobacco, soybean and wheat. Survey isoenzymes produced by resistant and susceptible lines using electrophoretic profiles to aide in locating potential genetic markers. Isolate and incorporate resistant genetic material in the plant breeding program.

Progress: 77/10 to 83/09. Over the life of B-127, research was focused on the following four areas: Examining the activity of peroxidase as a gene marker for ozone tolerance in tobacco; examining the effects of ozone on wheat cultivars grown in Maryland; the impact of ozone on the growth dynamics of tobacco, and investigating the effects of O(3) and SO(2) on nitrogen fixation and yields of soybean cultivars. The following conclusions may be drawn from the investigators: Peroxidase activity showed significant stimulations following exposure to ozone both in greenhouse and field studies; however, the magnitude of stimulation was variable across environments which suggest that it is too variable for use as a pollution tolerance screening device. Yields and grain quality were reduced in wheats exposed during flowering or throughout the growth of the plants. Significant differences were found among cultivars grown in Maryland. This research is being continued. Ozone was observed to significantly reduce the relative growth rates in four cultivars which differed significantly in visual responses. Therefore, ozone tolerance ratings should consider growth

in addition to visual leaf injury in breeding programs. Total nodule activity in soybeans was reduced following exposures to O(3) and S0(2). Also, grain yields were significantly reduced in field studies following pollution treatments at two growth stages.

Publications: 77/10 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

26.003 CRIS0082864
GENETIC AND ENVIRONMENTAL FACTORS AFFECTING MARYLAND TOBACCO CULTIVARS

MULCHI C L; MCKEE C G; AYCOCK M K JR;
Agronomy; University of Maryland, College Park,
MARYLAND 20742.
Proj. No.: MD-B-133 Project Type: STATE
Agency ID: SAES Period: 01 OCT 80 to 30 SEP 83

Objectives: To examine genetic and environmental factors, including curing, as they influence the chemical and physical characteristics of Maryland tobacco.

Approach: Planned investigations include: The continued development of low alkaloid cultivars. Low alkaloid offspring are backcrossed to Md 609. Cultivars of Maryland tobacco will be grown in the field in filtered air then exposed to simulated air pollution episodes using ozone. Growth parameters will be calculated from weight changes observed following treatments. Tobacco cultivars will be inoculated with Tobacco Etch Virus (TEV) and Tobacco Mosaic Virus (TMV) in greenhouse and field studies with emphasis on yield and changes in growth rates following inoculations.

Progress: 83/01 to 83/09. Polyacrylamide gel electrophoresis (PAGE) was examined as a cultivar identification tool for use in N.tabacum. Ten cultivars representing Maryland, flue-cured, burley and cigar type tobaccos were grown in the field and in two greenhouse studies and fresh leaf samples were collected (frozen via liquid N(2)) during three growth phases with the final samples being taken at flower initiation. Isozyme profiles were prepared for esterase, catylase, malate dehydrogenase and peroxidase with the numbers of bands being found across treatment equal to 3, 7, 9, and 11, respectively. It was possible to uniquely identify all ten cultivars with catalase, malate dehydrogenase and peroxidase showing the greatest variability. In general, the greatest variability was observed in younger tissue from the field study as compared to the greenhouse studies. Most cultivar differences were confined to one or two bands. Further studies on extraction and staining techniques are needed in order to standardize the procedures.

Publications: 83/01 to 83/09
MULCHI, C. L. and ARMBRUSTER, J. A. 1983. Chloride effects on agronomic, chemical and physical properties of Maryland tobacco - II. Response to soil vs. foliar applied salts of cooling tower origin. Tob. Sci. 27:45-50.

26.004* CRIS0069843
EFFECT OF AIR POLLUTANTS ON GROWTH AND YIELD OF FOREST TREES, ORNAMENTALS AND FIELD CROPS

MOORE L D; SKELLY J M; Plant Pathology & Physiology; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
Proj. No.: VA-0202390 Project Type: STATE
Agency ID: SAES Period: 01 JAN 76 to 30 SEP 82

Objectives: Evaluate the impact of air pollution found in Virginia on forest trees, woody ornamentals, and certain field crops. Determine how air pollution affects certain chemical constituents of plants. Develop practical measures of alleviating plant injury by cultural or genetic methods.

Approach: Selected species, cultivars and/or hybrids will be studied under field and controlled conditions. The effect of ambient and controlled levels of pollutants on growth and development will be determined. Radial increment growth studies and the development of a bioindicator system will be used to study pollution abatement programs. Selected plants will be assayed for certain chemical constituents. The influence on N, P, K, and Ca levels on the sensitivity of plants to pollutions will be ascertained.

Progress: 82/01 to 82/12. Five air pollution monitoring sites were maintained on the Blue Ridge and Appalachian Mountains of Virginia. Pollution intensity was determined over a 5-year period and correlated with damage to white pines. Significant reduction in foliar biomass of plants grown in non-filtered chambers at the sites showed that low levels of pollutions were detrimental. Ozone and sulfur dioxide tolerant plant material of azalea, rhododendron, white pine, loblolly pine and tobacco cultivars, lines and/or hybrids was identified. Studies of the importance of mineral nutrition in altering the sensitivity of tobacco and whitepine to ambient oxidant levels showed that N, P and Ca could be used to reduce pollution sensitivity. The use of specific herbicides to reduce the sensitivity of tobacco transplants to oxidants has been very successful. Investigations of the effects of pollution on numerous chemical constituents as well as plant biomass showed the importance of subclinical levels of pollution on tobacco production in Virginia. Results of this project are now being incorporated into agricultural practices in Virginia.

Publications: 82/01 to 82/12
BENOIT, L. F.. and SKELLY, J. M.. and MOORE, L. D.. and DOCHINGER, L. S., 1982, Radical growth reductions of Pinus strobus L. correlated with foliar ozone sensitivity., Can. J. Forest Res. 12:673-678.
REILLY, J. J.. and MOORE, L. D., 1982, Influence of selected herbicides on ozone injury in tobacco (Nicotiana tabacum), Weed Sci. 30:260-263.
DUCHELLE, S. F.. and SKELLY, J. M.. and CHEVONE, B. I., 1981, Oxidant effects on forest tree seedling growth in the Appalachian Mountains., Soil, Water, Air Pollut. 18:363-365.

PHILLIPS, S. O.. and SKELLY, J. M.. and BURKHART, H. E., 1977, Inhibition of growth in asymptomatic white pine exposed to fluctuating levels of air pollution., *Phytopathology* 67:721-725.

TREVATHAN, L. E.. and MOORE, L. D., 1981, A study of calcium fertilization on weather fleck and chemical composition of flue-cured tobacco., *Tobacco Sci.* 25:102-105.

26.005* CRIS0074470
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

CHEVONE B I; MOORE L D; WINNER W E; Plant Pathology Physiology & Weed Science; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
Proj. No.: VA-622292 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield, and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors. To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: Fumigate field crops and forest tree species with ozone, sulfur dioxide and nitrogen dioxide singly and in various combinations with acidic rain. Measure symptoms, growth parameters, chlorophyll, carbohydrates and sulfur levels. Inoculate pollution stressed plants with *Phytophthora* or *Collectotrichum* and determine the rates of disease development and the disease severity. Measure changes in carbohydrate and lipid levels in leaves and roots and absolute changes in enzymes and compounds involved in photosynthesis. Screen bean, pine, ash and tobacco cultivars, lines and introductions for tolerance to acidic rain, ozone and sulfur dioxide. Screening includes field trials and fumigation tests.

Progress: 84/01 to 85/09. Soybeans were exposed to 0.20 ppm ozone and 0.70 ppm sulfur dioxide in various combinations. Fumigations were administered for 2 h either as a single pollutant (O₃ or SO₂), simultaneously (O₃ + SO₂) or in overlapping pollutant combinations. After 2 h exposure to O₃ or SO₂ the carbon dioxide exchange rate (CER) was affected. Exposure to O₃ followed by O₃ + SO₂, SO₂ followed by SO₂ + O₂ and continuous O₃ + SO₂ significantly reduced CER. However, stomatal resistance was only altered by the simultaneous fumigation with O₃ + SO₂. These results suggest that SO₂ and O₃ affect different biochemical processes associated with CO₂ metabolisms. Plant species had patterns of visible foliar injury that reflected SO₂ - stress gradients near Hawaiian volcano vents. Injury reflected, in part, species differences in stomatal response to SO₂. The most seriously injured leaves do not close their stomata when exposed. The most SO₂ - resistant species were the most abundant indicating volcanic SO₂ may exert selective forces on community development. A general model of annual SO₂ absorption was

calculated for both mosses and vascular plants to determine if differences in absorption could account for extreme SO₂ sensitivity known for mosses. Analysis of SO₂ absorption took into account seasons, precipitation, evergreen forests, deciduous forests, arctic tundras, and deserts. SO₂ absorption for mosses ranged from 30 to 400 fold higher for mosses than for vascular plants.

Publications: 84/01 to 85/09 .
CHEVONE, B. I. and YANG, Y. S., 1985, CO(2) exchange rates and stomatal diffusive resistance in soybeans exposed to O₃ and SO(2), *Can. J. Plant Sci.* 65:267-274.
WINNER, W. E. and MOONEY, H. A., 1985, Ecology of SO(2) resistance V. Effects of Volcanic SO(2) on Native Hawaiian Plants, *Oecologia*, 66:387-393.
WINNER, W. E. and ATKINSON, C. J., 1985, Annual Absorption of Gaseous Air Pollutants by Mosses and Vascular Plants in Diverse Habitats, In: *The Effects of Acid Deposition on Forests, Wetlands, and Agricultural Ecosystems*. In Press.

26.006 CRIS0068052
CONTROL OF TOBACCO DISEASES

FULTON R W; NEWMAN R C; SEQUEIRA L; Plant Pathology; University of Wisconsin, Madison, WISCONSIN 53706.
Proj. No.: WIS05111 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 78 to 30 SEP 84

Objectives: To develop an early maturing Wisconsin tobacco variety resistant to black root rot, tobacco mosaic virus, races 0 and 1 of *Pseudomonas tabaci*, and ozone injury. To determine the nature of resistance to *P. tabaci* in this variety.

Approach: Genetically stable resistance to three pathogens is contained in present tobacco breeding lines, some of which also possess desirable earliness, yield, quality, and resistance to ozone injury. Continued backcrossing and field screening will be done to combine all desirable characteristics. The nature of resistance to *P. tabaci* race 1 will be compared with resistance to race 0 in rate of bacterial multiplication in resistant and susceptible varieties, effect of external factors on expression of resistance, and intercellular response of the varieties to the two races.

Progress: 84/01 to 84/12. This project was terminated 30 June 1984, consequently this report summarized information obtained since the project was activated. The occurrence of *Pseudomonas tabaci* infection ("wildfire") on a Wisconsin tobacco variety previously released as resistant was due to the development of a race (race 1) of the organism pathogenic on varieties that were resistant to the formerly common race 0. Numerous possible genetic sources of resistance to race 1 were tested. *Nicotiana rustica* was resistant to both race 0 and race 1; a breeding program was begun to incorporate this resistance into commercially acceptable lines of tobacco by crossing and

backcrossing. Selections made in the field were rated for resistance in greenhouse tests during the winter. Two lines of apparently satisfactory resistance, yield and quality have been in the hands of growers for their evaluation for the past two seasons. Seed of each of these is not available to certified seed growers. Another disease causing tobacco growers concern has been cucumber mosaic virus infection. Extensive tests made previously failed to detect appreciable resistance in any *Nicotiana* spp. or tobacco varieties. The source of virus infection has been weeds, particularly chickweed, (*Stellaria media*). Observational evidence indicated that the virus did not spread more than 20-40 meters from a source, suggesting that local weed control might provide a remedy.

Publications: 84/01 to 84/12

- SKOOG, H.A. and FULTON, R.W. 1976. Sources of resistance in the *Nicotiana* species to *Pseudomonas tabaci* virulent on TL 106-derived tobacco. *Proc. Am. Phytopath. Soc.* 3:231-232. (Abstr.)
- FULTON, R.W. 1980. Tobacco blackfire disease in Wisconsin. *Plant Dis.* 64:100.
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CM 30 BEEF CATTLE

30.001 CRIS0087284 INVESTIGATION INTO PHENOMENA GENETIC BASIS AND PREVENTION OF DISEASE

PHEMISTER R D; Veterinary Medicine; Colorado
State University, Fort Collins, COLORADO
80523.

Proj. No.: COL05418 Project Type: ANIMAL HEALTH
Agency ID: CSRS Period: 03 MAR 82 to 30 DEC 83

Objectives: Develop rapid economical procedures for quantitative assay of a broad spectrum of chemicals--contaminants, naturally occurring toxins and drugs--in animal tissues and feeds for use in diagnosis and monitoring of toxic products, and development of assays of interactions of toxic effects and stress conditions upon production and product quality/wholesomeness.

Approach: See objectives.

Progress: 83/01 to 83/12. Air quality, as defined by levels of total suspended particulates, carbon monoxide, ozone, nitrates and sulfates, was monitored and correlated to the incidence of disease, particularly respiratory diseases in approximately 20,000 feedlot cattle. There was one major increase in the incidence of pneumonia which followed by two weeks a peak in suspended particles in the air. Other upper respiratory infections were more directly correlated with increase in suspended particles. These data continue to be collected and the results will be subjected to time-sequence analyses. At least 18 months of data will be collected before final analysis.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

30.002 CRIS0075024 IMPACT OF EMISSIONS ON ECOSYSTEMS IN THE VICINITY OF A MOLYBDENUM CONVERSION PLANT IN LEE COUNTY

LLOYD W E; Veterinary Medicine; Iowa State
University, Ames, IOWA 50011.

Proj. No.: IOWV-400-23-86 Project Type: STATE
Agency ID: CSVN Period: 01 MAR 77 to 30 DEC 83

Objectives: The contamination of the environment by various metal smelting processes can constitute serious environment pollution. A new plant has been constructed for conversion of molybdenum. It is desirable to conduct studies of the natural background levels of several heavy metals in the vicinity of this plant and compare them with the levels that occur after this facility become operational.

Approach: Selected herds of cattle, fields of crops and indicator test plots within a 30 mile radius of the plant will be monitored for potential variations in trace elements, especially molybdenum, copper and fluorine.

Progress: 82/01 to 82/12. This project involves an ongoing study of the health of 4 cattle herds in the Ft. Madison, Iowa, area and 2 control herds in the Mt. Pleasant, Iowa area. During March and October of 1982 the herds were

examined and milk, feed and blood samples were collected. As of this data there are no significant increases in molybdenum concentrations in any of the 4 test herds near the AMAX molybdenum conversion plant nor in the Mt. Pleasant control herds. There have been no herd health problems which could be associated with excess dietary molybdenum. Plans are being made to make the final herd examination and collection of samples within the next two months.

Publications: 82/01 to 82/12
NO PUBLICATIONS REPORTED THIS PERIOD.

CM 31 DAIRY CATTLE

31.001* CRIS0075024
IMPACT OF EMISSIONS ON ECOSYSTEMS IN THE
VICINITY OF A MOLYBDENUM CONVERSION PLANT IN
LEE COUNTY

LLOYD W E; Veterinary Medicine; Iowa State
University, Ames, IOWA 50011.
Proj. No.: IDWV-400-23-86 Project Type: STATE
Agency ID: CSVN Period: 01 MAR 77 to 30 DEC 83

Objectives: The contamination of the environment by various metal smelting processes can constitute serious environment pollution. A new plant has been constructed for conversion of molybdenum. It is desirable to conduct studies of the natural background levels of several heavy metals in the vicinity of this plant and compare them with the levels that occur after this facility become operational.

Approach: Selected herds of cattle, fields of crops and indicator test plots within a 30 mile radius of the plant will be monitored for potential variations in trace elements, especially molybdenum, copper and fluorine.

Progress: 82/01 to 82/12. This project involves an ongoing study of the health of 4 cattle herds in the Ft. Madison, Iowa, area and 2 control herds in the Mt. Pleasant, Iowa area. During March and October of 1982 the herds were examined and milk, feed and blood samples were collected. As of this data there are no significant increases in molybdenum concentrations in any of the 4 test herds near the AMAX molybdenum conversion plant nor in the Mt. Pleasant control herds. There have been no herd health problems which could be associated with excess dietary molybdenum. Plans are being made to make the final herd examination and collection of samples within the next two months.

Publications: 82/01 to 82/12
NO PUBLICATIONS REPORTED THIS PERIOD.

31.002 CRIS0088961
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIAL

NIPPER W A; ADKINSON R W; NIPPER W A; Dairy
Science; Louisiana State University, Baton
Rouge, LOUISIANA 70803.
Proj. No.: LAB02306 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Assess the effects of atmospheric deposition on the following: The health and productivity of domestic food animals.

Approach: Effects on Livestock; effect of sulfur and heavy metals from the atmosphere on animals consuming forage. Effects on Aquatic Ecosystems; Influence of acid precipitation, toxic metals, and other toxic substances from the atmosphere on aquatic wildlife and domestic food animals.

Progress: 84/01 to 84/12. Objectives and Accomplishments: Trial 1: Preliminary development of procedures to analyze via ICP

the sulfur and nitrate content of milk continued with little success. If procedures can be finalized, a study relating the sulfur and nitrate deposition on pastures and milk levels will be completed. Trial 2: Procedures and techniques have been developed for evaluation of the effect of acid rain on forage digestibility. Ryegrass forage will be grown in a greenhouse and treated with four levels of simulated acid rain composed of nitric acid, sulfuric acid or a combination of both. In situ disappearance of dry matter, protein, ADF and cellulose will be measured.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

CM 33 SHEEP AND WOOL

33.001* CRIS0096632
THE RESPONSE OF RANGE PLANTS AND ANIMALS TO
VARIOUS TYPES OF GRAZING AND MANAGEMENT SYSTEMS

MURPHY A H; Agronomy & Range Science;
University of California, Davis, CALIFORNIA
95616.

Proj. No.: CA-D*-ARS-4567 Project Type: STATE
Agency ID: SAES Period: 01 OCT 85 to 30 SEP 87

Objectives: Grazing data to evaluate the impact of costs and returns for sheep use of grasslands and brush areas is being collected to better appraise the feasibility of various improvement practices. Measurements of both animals and forage need to be accomplished on a long-term basis. Where brushland improvement is practiced the environmental conditions relative to air pollution, water yield, and erosion need to be explored for more explicit information. The value of livestock for the control of woody species needs to be demonstrated as a method of biological control.

Approach: Field data from grazing studies will be analyzed with recommendation developed from data review. Measurement of annual forage yields will continue, compiling animal use on pastures where improvement studies are in progress.

CM 34 OTHER ANIMALS

34.001* CRIS0087284 INVESTIGATION INTO PHENOMENA GENETIC BASIS AND PREVENTION OF DISEASE

PHEMISTER R D; Veterinary Medicine; Colorado
State University, Fort Collins, COLORADO
80523.

Proj. No.: COL05418 Project Type: ANIMAL HEALTH
Agency ID: CSRS Period: 03 MAR 82 to 30 DEC 83

Objectives: Develop rapid economical procedures
for quantitative assay of a broad spectrum of
chemicals--contaminants, naturally occurring
toxins and drugs--in animal tissues and feeds
for use in diagnosis and monitoring of toxic
products, and development of assays of
interactions of toxic effects and stress
conditions upon production and product
quality/wholesomeness.

Approach: See objectives.

Progress: 83/01 to 83/12. Air quality, as
defined by levels of total suspended
particulates, carbon monoxide, ozone, nitrates
and sulfates, was monitored and correlated to
the incidence of disease, particularly
respiratory diseases in approximately 20,000
feedlot cattle. There was one major increase in
the incidence of pneumonia which followed by
two weeks a peak in suspended particles in the
air. Other upper respiratory infections were
more directly correlated with increase in
suspended particles. These data continue to be
collected and the results will be subjected to
time-sequence analyses. At least 18 months of
data will be collected before final analysis.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

34.002* CRIS0047438 EVALUATION OF RISK FROM LEAD AND OTHER HEAVY METALS PRESENT IN URBAN GARDEN & SMALL FARM SOILS

CHANEY R L; USDA Agricultural Research Service,
Beltsville, MARYLAND 20705.

Proj. No.: 1203-20793-009-000

Project Type: INHOUSE
Agency ID: ARS Period: 27 OCT 81 to 21 MAR 84

Objectives: Develop soil sampling and analysis
methods for high metal urban soils;
characterize metal sources for urban garden
soils and their impact on high-risk crops;
determine whether sludge compost or other
amendments can prevent accumulation of soil Pb
by lettuce; and determine whether amendments
can reduce the availability of soil Pb to
animals fed soils containing excessive Pb.

Approach: Evaluate methods for soil analysis on
high metal soils with varied chemical
properties; Evaluate methods of sampling
community gardens; conduct a survey of
Baltimore gardens to characterize the extent
and sources of garden soil metal pollution;
measure metal content of leafy vegetable crops
sampled in urban gardens; conduct pot studies
to determine whether phosphate fertilizer,
limestone, or sludge compost can reduce metal

uptake by leaf and root vegetables; conduct
soil feeding trials with rats to assess
bioavailability of soil Pb from different
pollution sources, and whether soil amendments
can reduce this bioavailability.

Progress: 81/10 to 84/04. Results from our
survey of heavy metals in garden soils in
Baltimore, MD were analyzed using a new
statistical procedure which calculates the
probability of Pb concentration in mapping
units. Both automotive Pb emissions and Pb
paint residues contributed to high accumulation
of Pb in inner city soils. These results were
published, and the journal prepared an
editorial discussing these results. Soil-plant
metal relationships in Baltimore gardens
research results have been incorporated into
manuscripts which are undergoing review.

Publications: 81/10 to 84/04

MIELKE, H.W., ANDERSON, J., BERRY, K., CHANEY,
R.L., LEECH, M.L. and MIELKE, P.W. 1983.
Lead concentration in inner city soils as a
factor in the child lead problem. Am. J.
Public Health.

CHANEY, R.L., and STERRETT, S.B. 1982. The
potential for heavy metal exposure from
urban gardens. In Symposium on Heavy Metals
in Urban Gardens. University of the
District of Columbia.

34.003 CRIS0095904 UNCERTAINTY AND IRREVERSIBILITY IN NATURAL RESOURCE USE

SEGERSON K; Agri Economics; University of
Wisconsin, Madison, WISCONSIN 53706.
Proj. No.: WIS02953 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 85 to 30 SEP 89

Objectives: Examine how the Wisconsin State
Legislature and regulatory bodies have dealt
with the uncertainty inherent in resource use
issues when determining natural resource
policies, and synthesize possible responses to
different types of uncertainty; develop a
general framework for analyzing resource use
decisions under uncertainty and
irreversibility; analyze how incentive
structures and/or liability rules could be used
under conditions of uncertainty to control
nonpoint pollution, acid rain, and groundwater
pollution from land disposal of hazardous
wastes; and compare these incentive or
liability structures to policies that are
currently in place or under discussion in
Wisconsin for control of these problems.

Approach: Examine and analyze recent
state-level actions that have embodied elements
of uncertainty and the past use of liability
rules; generalize economic concepts relating
decision-making under uncertainty to
incorporate continuous choices; and integrate
public and private decision-making models to
investigate the role of incentive structures
and liability rules in the context of nonpoint
pollution, acid rain and hazardous waste
management, and evaluate alternative policies
using criteria list.

CM 36 GENERAL PURPOSE SUPPLIES

36.001* CRIS0068090
NITROGEN AND SULFUR TRANSFORMATIONS IN SOILS
RELATED TO FERTILIZER AND POLLUTION PROBLEMS

BREMNER J M; Agronomy; Iowa State University,
Ames, **IOWA** 50011.
Proj. No.: IOWO2096 Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 75 to 30 SEP 83

Objectives: Obtain detailed information concerning nitrogen and sulfur transformations in soils related to fertilizer and pollution problems.

Approach: Processes responsible for volatilization of nitrogen and sulfur from soils, and factors affecting these processes, will be studied. The processes investigated will include denitrification, chemodenitrification, urea hydrolysis, sulfate reduction, and biodegradation of organic sulfur compounds. Methods of controlling nitrification, urea hydrolysis, and other nitrogen transformation processes in soils that affect crop utilization of nitrogen and contribute to air and water pollution problems will be evaluated, and factors influencing the effectiveness of nitrification and urease inhibitors will be determined. The fate of urease added to soils will be studied, and factors affecting urease activity and urease levels in soils and sorption of urea by soils will be investigated. The ability of soils to sorb sulfur and nitrogen gases identified as atmospheric pollutants, including NO , NO_2 , SO_2 , and H_2S , will be studied, and the potential value of soils for purification of air polluted by these gases will be assessed.

Progress: 83/11 to 83/12. No progress report this period.

Publications: 83/11 to 83/12

MARTENS, D.A. 1983. Effectiveness of phosphoroamides for retardation of urea hydrolysis in soils. M.S. Thesis, Iowa State Univ., Ames. 40 p.

CM 37 CLOTHING AND TEXTILES

37.001 CRIS0089702
ENVIRONMENTAL AND WET PROCESSING EFFECTS ON TEXTILES

LADISCH C M; Consumer Sci & Retailing; Purdue University, West Lafayette, **INDIANA** 47907.
Proj. No.: IND082035 Project Type: HATCH
Agency ID: CSRS Period: 15 MAR 83 to 30 SEP 87

Objectives: A study of the chemical and physical effects of environmental factors such as ultraviolet light, heat, and acid rain on textile fibers, fabrics, and dyes. A study of the effects of wet processing (i.e., dyeing and finishing) on textile performance properties.

Approach: The work required for the proposed objectives is primarily textile laboratory research. Simulation of environmental conditions, such as heat, light, humidity, ozone, and pollutants will be achieved in controlled simulation chambers according to the relevant standardized procedures. Following exposure to the desired environmental or wet processing conditions, the textiles will be evaluated for changes in color, performance properties such as strength, abrasion resistance, and wrinkle recovery and chemical properties such as molecular weight, reducing power, and reactivity.

Progress: 84/01 to 84/12. Progress on two projects related to the environmental and wet processing effects on textiles are reported here. (1) Eight different reactive dyes have been applied to cotton fabric and tested for colorfastness to light and for photosensitization of the cotton substrate. Depending upon the molecular structure of the dye and the nature of the bonding of the dye with the cellulose, the dyes either protected or accelerated degradation of the cotton fabric. (2) The effect of acid rain conditions on the performance of nylon 6,6 fabric has been determined. Nylon was found to degrade rapidly when exposed to pH 2.0 precipitation and this degradation was highly catalyzed by the addition of light exposure. Degradation was documented by changes in nylons molecular structure via amino end group analysis and viscometry measurements and by physical property changes, such as breaking strength of the fabric.

Publications: 84/01 to 84/12
KYLL0, K.E. and LADISCH, C.M. "Acid Rain Degradation of Nylon", AATCC Book of Papers, 361-368 (1983).

spectroscopy can be used as a tool to identify polymeric changes in nylon.

Approach: Nylon 6,6 fabric dyed with selected acid dyes will be exposed to simulated acid rain conditions using H(2)SO4 at pH 2.0, 3.0 and 4.0. Exposure conditions of 63+/-3 C and 65+/-5% relative humidity for 0, 80, 160, 320 and 640 AATCC fading units in both light and darkness will be used. Degradation of selected samples of each fabric in each exposure condition will be evaluated by tensile strength, tear strength, viscosity, amino end group concentration and color change. Selected samples will be evaluated using scanning electron microscopy and C NMR spectroscopy.

37.002 CRIS0092743
ACID RAIN DEGRADATION OF DYED NYLON

KYLL0 K E; Merchandising Consumer Studies& Design; University of Vermont, Burlington, **VERMONT** 05405.
Proj. No.: VT00391 Project Type: HATCH
Agency ID: CSRS Period: 26 MAR 84 to 30 SEP 87

Objectives: To determine if the presence of selected acid dyes will enhance or delay nylon polymer and fabric deterioration due to acid rain conditions. To determine if 13-Carbon NMR

38.001 CRIS0068611
STUDIES ON OXIDIZING AIR POLLUTION TOXICITY IN VIVO WITH SPECIAL REFERENCE TO VITAMIN E

CSALLANY A S; Food Science & Nutrition;
 University of Minnesota, St Paul, MINNESOTA
 55108.

Proj. No.: MIN-18-085 Project Type: STATE
 Agency ID: SAES Period: 01 JUL 77 to 30 SEP 87

Objectives: Elucidate the metabolic pathway of in vivo lipofuscin (age) pigment synthesis and degradation. Determine the influence of free radical initiators, vitamin E, age, selenium, glutathione peroxidase and alcohol dehydrogenase enzymes on pigment synthesis and decomposition. Characterize the composition of age pigments. Prove that the Schiff base moiety of age pigments are derived from peroxidizing polyunsaturated fatty acids in vivo via malondialdehyde (a known carcinogen) synthesis.

Approach: Uniformly labeled C-14 methyl linoleate and C-14 malondialdehyde will be used in animal experiments involving: Liver perfusion, I.V. injection and feeding for elucidation of metabolic pathway of pigment formation and for the determination of precursory role of malondialdehyde in pigment formation. The influence of enzymes, age, selenium, free radicals initiators (O(3) NO(2)) and vitamin E on pigment levels will be followed by animal studies. Characterization studies of pigments will involve; isolation, degradation, amino acid analysis and other chemical and spectral identifications.

Progress: 84/01 to 84/12. As a combination of the long term study to determine the effect of ozone on in vivo lipid oxidation fluorescent, water-soluble materials and organic solvent soluble lipofuscin pigments were separated and quantified in ozone exposed mouse livers from all dietary groups. Results are currently being analyzed statistically. Both retinol and retinyl palmitate concentrations were significantly reduced in the lung due to ozone (0.5 ppm) compared to ambient air and the lower level of ozone (0.25 ppm) in vitamin E deficient, normal and high vitamin E supplemented mice. The level of thiobarbituric acid reactive substances (TBA) was determined in the mouse lung to assess the effects of ozone exposure, dietary antioxidant and different dietary fats on in vivo lipid oxidation. No ozone effect has been found on lung TBA value in any dietary group. Significantly higher levels of TBA reactive materials were found in the vitamin E deficient groups. The TBA reactive substances were determined in the plasma and urine of rats fed different levels of dietary vitamin E for 10 months. Vitamin E deficient groups showed significantly higher levels of TBA reactive materials than in vitamin E supplemented groups. Fractionation of urine from vitamin E deficient rats on TSK 1000 pw column by high performance liquid chromatography showed a total of four TBA reactive substances indicating that beside malondialdehyde other oxidative degradation products of lipids exist in the urine.

Publications: 84/01 to 84/12

- CSALLANY, A.S., SU, L.C. and MENKEN, B.Z.
 1984. Effect of selenite, vitamin E and N, N'-diphenyl-p-phenylene-diamine on liver organic solvent-soluble lipofuscin pigments in mice. J. Nutr. 114:1582-1587.
- CSALLANY, A.S., AYAZ, K.L. and MENKEN, B.Z.
 1984. Effect of dietary vitamin E upon fluorescent compounds of the rat uterus. Lipids. 19:911-915.
- MENKEN, B.J., KINDOM, S.E. and CSALLANY, A.S.
 1984. Effect of ozone exposure and diet on catalase, glutathione peroxidase and superoxide dismutase activities in mouse livers. Fed. Proc. 43:760 (Abst. 2780).
- CSALLANY, A.S., MENKEN, B.Z., HA, Y.L. and LEE, H.S. 1985. Chronic effect of long-term ozone exposure and diet on fat soluble vitamins and lipid oxidation products. Fed. Proc. (In press.).

CM 40 PEOPLE AS WORKERS, CONSUMERS, AND MEMBERS OF SOCIETY

40.001* CRIS0074466
**CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND
EFFECTS ON LAND AND SURFACE WATERS**

BURGY R H; MYRUP L O; Land, Air & Water
Resources; University of California, Davis,
CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-3619-RRProject Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establishing an Atmospheric
Deposition Network to determine spatial and
temporal trends in the supply of beneficial
nutrient elements and potentially injurious
substances in precipitation and dry particulate
matter deposited in various regions of the
United States. Developing optimum procedures
for collecting precipitation (regular timed
sampling and event sampling) and dry
particulate matter (open containers,
air-filtration collectors and biological
collectors). Determining the stability of
certain constituents of precipitation during
collection, transport and storage prior to
analysis. Investigating the transport and
transformations of atmospheric constituents.
Organizing and coordinating research is the
SAES, FS and other research institutions and
agencies on the effects of changes in
atmospheric deposition.

Approach: For all objectives listed, utilizing
a network sampling station and specifications
developed by the Regional Project, the data
collection, processing analysis and
interpretation will be adapted to project
requirements. Special studies are to be devised
in concert with project subcommittee
coordination.

Progress: 79/09 to 83/09. The data
acquisition site in the National Atmospheric
Deposition Program has been operational since
the Fall of 1979. During the first three years
of operation only the rainfall season
collections were made in the period of
September through May. In 1982, the project
operation was made to conform to the NADP
standards and schedule with full seasonal data
collection made weekly throughout the year.
During the five years of records acquired at
the station a trend is observable in the
measured hydrogen ion concentration (pH) of
sampled rainfall, tending to become more
neutral with pH approaching 5.6. Occasional
samples are measured with both higher and lower
pH values. Improvement in the station operating
procedures and in the handling and processing
both in field and laboratory may account for
some reduction in the occurrence of low pH
values. Other factors may include improved
environmental conditions upwind from the site
due to reduced emissions of NO(x) compounds for
metropolitan areas and possibly to general
shifts in weather phenomena transporting the
precipitation products into the region. Based
on the record of the site, a general conclusion
may be indicated toward low acidic
precipitation input in that area of California.
The project has been replaced by Inter-Regional
Project IR-7, effective October, 1983.

Publications: 79/09 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

40.002* CRIS0075024
**IMPACT OF EMISSIONS ON ECOSYSTEMS IN THE
VICINITY OF A MOLYBDENUM CONVERSION PLANT IN
LEE COUNTY**

LLOYD W E; Veterinary Medicine; Iowa State
University, Ames, IOWA 50011.
Proj. No.: IOWV-400-23-86 Project Type: STATE
Agency ID: CSVM Period: 01 MAR 77 to 30 DEC 83

Objectives: The contamination of the
environment by various metal smelting processes
can constitute serious environment pollution. A
new plant has been constructed for conversion
of molybdenum. It is desirable to conduct
studies of the natural background levels of
several heavy metals in the vicinity of this
plant and compare them with the levels that
occur after this facility become operational.

Approach: Selected herds of cattle, fields of
crops and indicator test plots within a 30 mile
radius of the plant will be monitored for
potential variations in trace elements,
especially molybdenum, copper and fluorine.

Progress: 82/01 to 82/12. This project
involves an ongoing study of the health of 4
cattle herds in the Ft. Madison, Iowa, area and
2 control herds in the Mt. Pleasant, Iowa area.
During March and October of 1982 the herds were
examined and milk, feed and blood samples were
collected. As of this data there are no
significant increases in molybdenum
concentrations in any of the 4 test herds near
the AMAX molybdenum conversion plant nor in the
Mt. Pleasant control herds. There have been no
herd health problems which could be associated
with excess dietary molybdenum. Plans are being
made to make the final herd examination and
collection of samples within the next two
months.

Publications: 82/01 to 82/12
NO PUBLICATIONS REPORTED THIS PERIOD.

40.003* CRIS0081767
**FURNACE TESTING OF THE COMBUSTION
CHARACTERISTICS OF AGRICULTURAL DUSTS**

LESTER T W; MERKLIN J F; Nuclear Engineering;
Kansas State University, Manhattan, KANSAS
66506.
Proj. No.: KAN-05-827
Project Type: SPECIAL GRANT
Agency ID: CSRS Period: 01 JUL 80 to 31 DEC 82

Objectives: A two year experimental program is
undertaken to determine the firing and
pollution formation characteristics of the
suspension firing of agricultural dusts. The
program will provide information on what
conditions of suspension firing will minimize
the potentially large nitric oxides formation
from easily evolved nitrogen bound into the
dusts. Additionally, the co-firing with coal
will determine to what extent ash from

agricultural fuels can reduce SO₂ emissions from high sulfur coal.

Approach: A scale model furnace, fully instrumented and capable of simulating the conditions in the primary flame zone of suspension fired furnaces, will be used as the test facility.

Progress: 80/07 to 82/12. Tests to determine the levels of nitrogen oxide emissions and the success of combustion modifications in their control from the combustion of agricultural and forest residues have been concluded. It was observed that the nitrogen oxide emissions from the forest residues were comparable to those obtained from the firing of natural gas because of the low inherent fuel-bound nitrogen content of those fuels. On the other hand, the nitrogen oxide emissions from the firing of wheat straw and corn stover were comparable to those generated from the firing of pulverized coals with equivalent nitrogen contents (1-2%). Consequently, the uncontrolled firing of these residue fuels in small utility and industrial boilers is apt to cause emissions exceeding regulated levels for units of greater than 250,000 lbs./steam-hr. The firing of these biomass fuels with various pulverized coals resulted in nitrogen oxide emissions significantly greater than from either the coal or the biomass fuel by itself. This increase, which is up to 20%, may be due to the large amounts of readily evolved oxygen from the biomass that reacts with the evolved nitrogen in the early stages of the flame.

Publications: 80/07 to 82/12

- ZAMANI, H.S. 1983. Nitrogen oxide emissions from the combustion of agricultural residue/pulverized coal mixtures. M.S. Thesis, Kansas State University, Manhattan.
- ROENIGK, R.A. 1983. Ammonia and hydrogen cyanide production during the combustion of agricultural residue/pulverized coal mixtures. M.S. Thesis. Kansas State University, Manhattan.
- LESTER, T.W., MERKLIN, J.F., ZAMANI, H. and ROENIGK, R.A. 1983. No(x) formation from the combustion of agricultural and forest residues. The Combustion Institute/Central States Section 1983 Spring Meeting. (Accept. for pub.).

and sources, and to determine some effects of communication on community opinion; to conduct a more extensive investigation of Adirondack community concerns and opinions about acid precipitation issues and to determine, more precisely communication influence on these opinions and perceptions; to analyze media reports about acid precipitation appearing in local community media and in major regional and national media available to community residents.

Approach: Study will be conducted over a three-year period, using personal interviews and self administered techniques.

40.004 CRIS0095349
**EFFECTS OF COMMUNICATION ON PUBLIC OPINION
 ABOUT ACID PRECIPITATION ISSUES**

GLYNN C J; Communication Arts; Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-131409 Project Type: HATCH
 Agency ID: CSRS Period: 01 APR 85 to 30 SEP 88

Objectives: To investigate the effects of communication on opinions and perceptions of issues among groups impacted upon by acid precipitation; to investigate the segmentation of the public and the differential communication needs of these segments. To conduct a preliminary in-depth study of one small Adirondack community to determine member's concerns and major communication needs

CM 43 COMMUNITIES, AREAS, AND REGIONS

43.001* CRISO120146 INDUSTRIAL AND AGRICULTURAL POLLUTION IMPACTS

BARSE J; USDA Economic Research Service,
Washington, DISTRICT OF COLUMBIA 20250.
Proj. No.: NRED-EIRS-4798 Project Type: INHOUSE
Agency ID: ERS Period: 01 OCT 83 to 30 SEP 86

Objectives: Calculate economic benefits to farmers, by region, and to consumers of alternative strategies to mitigate crop damage caused by gaseous air pollutants, principally ozone and sulfur dioxide.

Approach: Evaluate the degree of physical and economic damage to agricultural land and water, including groundwater, from toxic residuals, such as industrial chemical waste dumps.

Progress: 83/10 to 84/09. Literature in the physical and biological sciences and in economics on the impacts of air pollutants and acid rain on agriculture have been reviewed. An annotated bibliography, reflecting this review has been prepared and peer reviewed, and is to be published in FY 1985. Analytical work to project the economic impacts of ozone pollution on agricultural producers and consumers of farm products has started. The extent of groundwater pollution from toxic residuals, including those from pesticides and fertilizers as well as hazardous chemical wastes, is being evaluated. Planning is starting to analyze economic impacts upon rural areas once the extent of such pollution of groundwater is understood.

Publications: 83/10 to 84/09
NO PUBLICATIONS REPORTED THIS PERIOD.

43.002 CRISO084460 ECONOMIC TRENDS AND RELATIONSHIPS INFLUENCING OREGON AGRICULTURE

NELSON A G; MILLER S F; WEBER B A; Agri &
Resource Economics; Oregon State University,
Corvallis, OREGON 97331.
Proj. No.: ORE00803 Project Type: STATE
Agency ID: SAES Period: 01 JUL 81 to 30 JUN 86

Objectives: Analyze historical trends relating to agricultural production and marketing in Oregon; estimate production, supply and demand relationships pertaining to Oregon agricultural enterprises; identify key factors, constraints and conflicts that will influence the future of agricultural enterprises; project likely future directions for agricultural development in Oregon.

Approach: Secondary data and periodic surveys, to monitor trends. Data collected under Procedure 1 will be used to estimate demand, supply and input-output relationships. Models of the phenomena involved will be developed using budgeting, mathematical programming and econometric/statistical methods. Applying the models developed in Procedure 2, factors and constraints will be identified. Such factors may be energy price and availability, water price and availability, environmental legislation. Using techniques and models developed under Procedure 2, alternative

scenarios that account for constraints and changing conditions identified in Procedure 3 will be evaluate with respect to their economic impact on Oregon's agricultural sector.

Progress: 84/01 to 84/12. This project continues to examine economic trends and relationships affecting Oregon agriculture. An index system was developed to adjust custom rates for changes in fuel, repair, labor and machinery prices from one year to the next. The index indicated a cost increase of 3.7 percent for 1983 compared to 1982 and 4.7 percent for 1984 compared to 1983. Another phase of this research found that the long range transport of air pollutants from urban to rural areas in adversely affecting crop yields. Accurate assessments of the economic effects of air pollution are needed to set efficient control policies. Several economic assessment procedures are available to measure such benefits. Application of these assessment procedures indicates that the income of individual producers as well as that of consumers of agricultural products would be increased with reductions in air pollution.

Publications: 84/01 to 84/12
NELSON, A.G. Guildelines for Setting Custom Farming Rates. Oregon Farmer-Stockman 107 (April 5, 1984):22.
BUERKIN, K., BURT, L. and MILES, S. The Oregon Wine Industry - Historical Perspectives and the Current Production and Cost Situation. OSU Extension Service Extension Miscellaneous 8264, January 1984, 34 p.
HECK, W.W., ADAMS, R.M., et al. A Reassessment of Crop Loss from Ozone. Environmental Science & Technology 17(December 1983):539-548.
ADAMS, R.M. Issues in Assessing the Economic Benefit of Ambient Ozone Control: Some Examples from Agriculture. Environment International 9(December 1983):539-548.
MUELDE, J.W., ADAMS, R.M., DIXON, B.L. and GARCIA, P. Using Farmers' Actions to Measure Crop Loss Due to Air Pollution. Journal of the Air Pollution Control Association 31(April 1984):360-364.

CM 44 AGRICULTURAL ECONOMY OF THE UNITED STATES

44.001* CRIS0084460
**ECONOMIC TRENDS AND RELATIONSHIPS INFLUENCING
OREGON AGRICULTURE**

NELSON A G; MILLER S F; WEBER B A; Agri &
Resource Economics; Oregon State University,
Corvallis, OREGON 97331.
Proj. No.: ORE00803 Project Type: STATE
Agency ID: SAES Period: 01 JUL 81 to 30 JUN 86

Objectives: Analyze historical trends relating to agricultural production and marketing in Oregon; estimate production, supply and demand relationships pertaining to Oregon agricultural enterprises; identify key factors, constraints and conflicts that will influence the future of agricultural enterprises; project likely future directions for agricultural development in Oregon.

Approach: Secondary data and periodic surveys, to monitor trends. Data collected under Procedure 1 will be used to estimate demand, supply and input-output relationships. Models of the phenomena involved will be developed using budgeting, mathematical programming and econometric/statistical methods. Applying the models developed in Procedure 2, factors and constraints will be identified. Such factors may be energy price and availability, water price and availability, environmental legislation. Using techniques and models developed under Procedure 2, alternative scenarios that account for constraints and changing conditions identified in Procedure 3 will be evaluate with respect to their economic impact on Oregon's agricultural sector.

Progress: 84/01 to 84/12. This project continues to examine economic trends and relationships affecting Oregon agriculture. An index system was developed to adjust custom rates for changes in fuel, repair, labor and machinery prices from one year to the next. The index indicated a cost increase of 3.7 percent for 1983 compared to 1982 and 4.7 percent for 1984 compared to 1983. Another phase of this research found that the long range transport of air pollutants from urban to rural areas in adversely affecting crop yields. Accurate assessments of the economic effects of air pollution are needed to set efficient control policies. Several economic assessment procedures are available to measure such benefits. Application of these assessment procedures indicates that the income of individual producers as well as that of consumers of agricultural products would be increased with reductions in air pollution.

Publications: 84/01 to 84/12

NELSON, A.G. Guidelines for Setting Custom Farming Rates. Oregon Farmer-Stockman 107 (April 5, 1984):22.

BUERKIN, K., BURT, L. and MILES, S. The Oregon Wine Industry - Historical Perspectives and the Current Production and Cost Situation. OSU Extension Service Extension Miscellaneous 8264, January 1984, 34 p.

HECK, W.W., ADAMS, R.M., et al. A Reassessment of Crop Loss from Ozone. Environmental Science & Technology 17(December 1983):539-548.

ADAMS, R.M. Issues in Assessing the Economic Benefit of Ambient Ozone Control: Some Examples from Agriculture. Environment International 9(December 1983):539-548.
MUELDE, J.W., ADAMS, R.M., DIXON, B.L. and GARCIA, P. Using Farmers' Actions to Measure Crop Loss Due to Air Pollution. Journal of the Air Pollution Control Association 31(April 1984):360-364.

48.001 CRIS0085673
RURAL LAND MARKETS AND PROPERTY TAX POLICY IN
NEW YORK STATE

BILLS N L; BOISVERT R N; ALLEE D J; Agri
Economics; Cornell University, Ithaca, NEW YORK
14853.

Proj. No.: NYC-121415 Project Type: HATCH
Agency ID: CSRS Period: 02 OCT 81 to 30 SEP 85

Objectives: Analyze factors influencing the timing, volume and location of land transfers; develop implications for policies related to land utilization and the local property tax.

Approach: Initial phase involves assembly of land transactions data and information regarding the tax rolls of the state. Extensive use will be made of files maintained by the NYS Board of Equalization and Assessment. Models of differential tax incidence will be developed to facilitate the analysis of alternate property tax policies.

Progress: 84/01 to 84/12. Acid rain has been shown to impact the fishing values of a number of New York lakes. A limited study of sales over two years indicated that values were depressed on lakes with both low and high pH readings. A more extensive review of sales showed less conclusive results because the impacted lakes tend to be small with little developed shoreline. Sales tend to be concentrated along larger less impacted lakes and thus the results were not statistically significant. Further, it appears that fishing values are not a significant part of the premium paid for water access. Thus, the effect of reduced fishing success would not show in the sales of lakeside property.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

61.001* CRIS0065152 CHEMICAL NUTRITION OF AQUATIC MACROPHYTES

PEVERLY J H; Agronomy; Cornell University,
Ithaca, NEW YORK 14853.
Proj. No.: NYC-125420 Project Type: HATCH
Agency ID: CSRS Period: 05 OCT 82 to 30 SEP 86

Objectives: To measure cation (K, Al, Ca) content of plant, water, and sediment phases for lakes and ponds with a variety of chemical regimes. To determine importance of root and shoot absorption for these cations. To determine roles of cations (H, K, Al, Ca) in growth and nutrition of aquatic plants.

Approach: Associations of high tissue cation contents with other nutrients, with sediment and water concentrations, and with certain plant growth characteristics will be used as a basis of experimentation at the field and laboratory level. These experiments will confirm the evidence of cation roles in nutrition of macrophytes under a range of chemical regimes and growth habit. Examination of physiological response will increase our ability to predict reactions to changing environments.

Progress: 83/01 to 83/12. Field studies of both hard-water (Otsego Lake, NY) and soft-water (Adirondack) macrophyte communities indicate that aquatic plant growth may be limited by P or K, while tissue N is generally present in sufficient quantities for normal development. Samples of water, pore water, sediment, and plant tissues from acidic soft-water lakes had considerably higher Al concentrations than did samples from neutral soft-water lakes. Laboratory studies were designed to investigate the effects of low pH and increased Al concentrations of growth of *Eriocaulon septangulare*, a common species in these soft waters. Results obtained thus far show that *Eriocaulon* utilizes free CO₂ and not bicarbonate (HCO₃⁻) as a carbon source; data on carbon fixation rates are being analyzed to determine compensation point and saturation values of CO₂. Experiments conducted to detect Al toxicity are not complete but results suggest that effects, if any, are indirect through its effects on P availability or metabolism, rather than direct. Relationships between Al and phosphorus metabolism in *Eriocaulon* will be investigated in laboratory experiments during the next year. Field and laboratory studies have been funded in part through grants from the A.W. Mellon Foundation to Dr. G.E. Likens (Institute for Ecosystem Studies, New York Botanical Garden, Carey Arboretum, Millbrook, New York).

Publications: 83/01 to 83/12

- BEST, M.D., and PEVERLY, J.H. 1983. Aquatic vegetation in Adirondack Lakes: Field observations and experiments with pH, DIC, and Al. pp. 71-78. In: C.D. Collins (Ed.) The Lake George Ecosystem, Vol. III. The Lake George Association.
- BEST, M.D., and PEVERLY, J.H. 1982. Responses of aquatic vegetation to increased aluminum in acidified waters. Agronomy Abstracts, 1982:25.

BEST, M.D., and PEVERLY, J.H. 1982. Water and sediment chemistry and elemental composition of macrophytes in fifteen Adirondack Lakes. pp. 77-80. In: J.S. Jacobson (Ed.). Proc. N.Y.S. Symposium on Atmospheric Deposition.

61.002* CRIS0085227 MODE OF ACTION OF SELECTED HERBICIDES AND HERBICIDE ANTIDOTES

HATZIOS K K; Plant Pathology & Physiology;
Virginia Poly Inst, Blacksburg, VIRGINIA
24061.

Proj. No.: VA-0612431 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Study the mode of action of selected herbicides and herbicide antidotes at cellular and subcellular levels to facilitate comprehension of aberrations in physiological functions of selected crop or weed plant species exposed to these chemicals. Study the phytotoxicity of the major metabolites of selected herbicides to determine whether metabolic modification of the parent herbicide molecules by higher plants leads to reduced or increased herbicidal activity.

Approach: Time-course and concentration studies including periods of 30, 60 and 120 min and concentrations of 0, 0.1, 1, 10, and 100 (u)M will be used to examine the effects of these chemicals on photosynthesis, protein, RNA, and lipid synthesis of enzymatically isolated leaf cells or protoplasts of selected crop or weed species. The cells or protoplasts will be incubated with radioactive substrates specific for each metabolic process to be studied. Analyses will include extraction, spectrophotometry and scintillation detection procedures. Interaction studies examining the effects of antioxidants and of the air pollutant oxone (O₃) on the activity of selected herbicides in the presence or absence of specific herbicide antidotes will also be examined.

Progress: 84/01 to 85/09. Studies with safened and unsafened corn showed that in the presence of the safener R-25788 (N,N-diallyl-2,2-dichloroacetamide) the thiocarbamate herbicide EPTC interacted synergistically with the air pollutant ozone and the antioxidants piperonyl butoxide and propyl gallate. Because the antioxidants piperonyl butoxide and propyl gallate act as inhibitors of mixed-function oxidases, it was concluded that R-25788 may protect grass crops against injury from thiocarbamate herbicides by stimulating the metabolic degradation of these herbicides in the protected plants. Naphthalic anhydride (NA) was the most effective of four antidotes tested as safeners for protecting corn against injury from the herbicide isouron. Cyometrinil, CGA-93194 alpha-(1,3-dioxolan-2-yl-methoxy-imino)-benzenecetonitrile, and R-25788 were ineffective as protectants of corn against this herbicide. NA and seven of its structural analogues applied as seed dressings of 0.5 and 1.0% by seed weight offered satisfactory protection to

'XL72AA' corn hybrid against injury from the herbicide EPTC. These analogues included the compounds: acenaphthenequinone, 4-amino-1,8-naphthalic anhydride, 1,4,5,8-naphthalenetetracarboxylic dianhydride, 1,8-naphthalimide, 4-chloro-1,8-naphthalic anhydride, diphenic anhydride and phthalic anhydride. The same antidotes antagonized significantly the EPTC activity on 'XL67' corn hybrid but the protection offered was partial and agronomically important.

Publications: 84/01 to 85/09

HATZIOS, K. K., 1983, Interactions of the herbicides EPTC and EPTC plus R-25788 with ozone and antioxidants in corn, J. Agric. Food Chem. 31:1187-1191.

HENRY, W. T. and HATZIOS, K. K., 1985, Interactions between the herbicide isouron and selected antidotes on two corn hybrids, Cereal Res. Comm. 13:000-000(In press).

HATZIOS, K. K. and ZAMA, P., 1985, Physiological interactions between the herbicide EPTC and selected analogues of the antidote naphthalic anhydride on two hybrids of corn, Pestic. Sci. 16:000-000 (In press)

CM 63 BIOLOGICAL CELL SYSTEMS

63.001*

CRIS0069924

EXPLORATORY RESEARCH IN CHEMISTRY

ABBOTT E H; Chemistry; Montana State University, Bozeman, MONTANA 59717.
Proj. No.: MONB00254 Project Type: STATE
Agency ID: SAES Period: 01 JUL 82 to 30 JUN 99

Objectives: To enable chemistry station scientists to handle miscellaneous chemical problems of interest to agriculture which frequently turn up and seem to require prompt attention. Usually these problems will require only a limited amount of work either to provide a solution or to determine whether a full scale investigation is advisable. In the latter case, a research proposal would be prepared and submitted.

Approach: Chemistry faculty who feel that they have identified a problem of immediate importance to agriculture and who wish to seek support under this project will prepare a proposal outlining the problem, its relevance to agriculture, the approach to be taken, and a budget. The proposal will be reviewed by MAES staff and the project leader will determine whether funds should be allocated to the proposed study. Scientists receiving funds from this project will follow the same reporting procedures applicable to other station projects.

Progress: 84/01 to 84/09. One concern of acid deposition is how increased acidity alters the interaction of trace metal complexes with soil materials. Laboratory studies currently in progress are investigating the interaction of a series of cadmium complexes with hydrous aluminum oxide. The ligands, nitrilotriacetic acid, ethylenediamine-diacetic acid, diethylenetriaminemonoacetic acid and triethylenetetramine are all tetradentate but provide cadmium complexes of varying charge. The interactions of these complexes with the solid material is being monitored with different of pulse polarography. To date the CdNTA system is fairly well characterized. In general hydrous aluminum oxide absorbs sizeable amounts of this complex and the process is hydrogen ion dependent. A second part of this project entails the characterization and synthesis of commercially important organic chemicals of significance to Montana Agriculture. Work completed includes the identification and study of new phytotoxins, insecticides, pheromones, antiviral chemicals, and compounds which speed plant growth. The Cardellina group is exploring the development of new agrochemicals from natural sources - terrestrial plants and marine fauna and flora. Isolation, identification and in house bioassays for plant growth regulatory, antimicrobial and insecticidal activity are the central features of this research program.

Publications: 84/01 to 84/09

ARMOLD, A. and AMEND, J. (1984) The grazing land simulator; compiled for public education. Proceedings of Laramie Conference of Great Plains Agricultural Council.

CM 65 INVERTEBRATES

65.001 CRISO088328
AQUATIC INSECTS IN RELATION TO WATER QUALITY

GIBBS K E; Entomology; University of Maine,
Orono, MAINE 04469.
Proj. No.: ME08505 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Document structure and function of benthic macroinvertebrate communities in Maine. Study short- and long-term effects of benthic macroinvertebrate communities of aquatic perturbations from industrial and domestic effluent, aerial application of pesticides and wood harvesting practices. Provide information on the macroinvertebrate communities of ponds of differing pH as part of a cooperative study to elucidate benthic structure and ecosystems functions in these ponds.

Approach: The identity and distribution of aquatic macroinvertebrates of Maine will be studied with emphasis on floodplain species. Long-term changes in the fauna of the Penobscot River and ponds contaminated by carbaryl will be studied. The biomass, abundance and identity of macroinvertebrates of two ponds of differing pH will be documented.

Progress: 83/10 to 84/09. The macroinvertebrate fauna of the South Branch of the Carrabassett River watershed in the Sugarloaf Mountain area was surveyed with emphasis on identifying the black fly species present. Twelve species have been identified thus far. The impact of an 1980 experimental direct aerial application of carbaryl (Sevin-4-oilR) was found to be most severe and persistent on Amphipoda. In one of the treated ponds amphipod numbers of *Hyalella azteca* remained low and *Crangonyx ridgewayi* failed to recolonize during 1983. The macroinvertebrate fauna of two similar ponds of differing acidity were compared. In Salmon Pond (pH 6.8) and Mud Pond (pH 4.7) there were no significant differences in abundance or biomass in shallow (.5m) areas but abundance and biomass were significantly higher in deeper (2 - 4 m and 9 - 12 m) areas in Salmon than in Mud Pond. The Chironomidae differed in abundance and in genera present. Fish enclosure traps indicated that fishes may have an impact on the benthic macroinvertebrates. In fishless Mud Pond there were over three times as many organisms outside fish exclusion traps as inside; this can be considered a cage effect. In Salmon Pond, the cage effect was counter balanced by the fact that fish were excluded; the numbers inside and outside the traps were equivalent.

Publications: 83/10 to 84/09

GIBBS, K.E., MINGO, T. M. and COURTEMANCH, D.L. 1984. Persistence of carbaryl (Sevin-4-oilR) in woodland ponds and its effects on pond macroinvertebrates following forest spraying. Can. Ent. 116: 203-213.

65.002* CRISO091189
PALEOECOLOGICAL STUDY OF EFFECTS OF LAKE ACIDIFICATION ON CHIRONOMID COMMUNITIES

MITCHELL M J; School of Biology Chem & Ecolo;
State University of New York, Syracuse, NEW YORK 13210.
Proj. No.: NYZ-2222-01-007 Project Type: STATE
Agency ID: OCI Period: 01 MAY 83 to 31 DEC 85

Objectives: To examine the extant benthic communities in series of lakes with different pH levels from the Adirondack mountain region. To examine the stratigraphy of chironomid head capsule remains in sediments for assessing the time frame of acidification and its effects on chironomid communities. To synthesize study results with concomitant studies on the same lakes which are examining watershed geology and vegetation, water chemistry and the stratigraphy of chemical constituents and diatom remains.

Approach: Ten Adirondack lakes with a range of pH conditions will be examined for chironomid remains. Extant benthic communities will be analyzed using core samples, a dredge sample, taxa identification, and sample dating in these lakes and an additional ten lakes for calibrating the effect of water chemistry on the chironomid community.

Progress: 83/10 to 84/09. We are examining the stratification of chironomid head capsule remains in the recent sediments of seven Adirondack lakes. Temporal changes in chironomid community structure which have occurred during the last 200 years are being related to acidification and other watershed disturbances. The extant chironomid communities of the seven lakes, plus 13 additional lakes are also being sampled. The extant data are providing additional information on how chironomid communities vary with pH, which will aid in interpreting the stratigraphic profiles. The data available to date indicate that acidification has not caused drastic changes in chironomid community structure. The dominant taxa appear to be eurytopic and are not strongly, if at all, affected by increased acidity. Some of the less abundant taxa appear to be useful indicators of acidification. For example, the chironomid stratigraphy of Deep Lake (present pH = 4.6) shows changes which are indicative of acidification beginning after 1930. This corresponds well with the diatom stratigraphy of Deep Lake, which indicates a pH reduction beginning after 1940.

Publications: 83/10 to 84/09
NO PUBLICATIONS REPORTED THIS PERIOD.

CM 66 MICROORGANISMS

66.001* CRIS0074071
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

MANNING W J; FEDER W A; Plant Pathology; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
 Proj. No.: MAS00435 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors.

Approach: Whole plant responses of tolerant and sensitive cultivate cultivated plants and forest trees will be identified and used to determine responses to ozone and sulfur dioxide. Plant indicators of air pollution will be determined and used to determine air quality through development of dose/response cures. Work will continue on ozone and sulfur dioxide effects on root disease and nodulation of legumes. The effects of elevated heavy metal content of soils on plant sensitivity to pollutants will be determined. Work will begin on acid rain/gaseous air pollutant interactions.

Progress: 83/10 to 84/09. Set up ozone monitoring at Arnold Arboretum, Boston, MA about 10 miles east of Suburban Experiment Station in Waltham, MA. This allowed us to measure air quality on site of the Harvard University, Arboretum large lilac variety collection where leaf roll symptoms have been observed for many years. We could then compare air quality at Waltham and at the Arboretum. Both sites had very similar air quality patterns during summer of 1984. High and prolonged ozone episodes occurred at both sites during late June, early July 1984. Values ranged from 0.1-0.2 ppm for at least 4 hours daily for as long as 3-6 days at a time. Leaf roll symptoms occurred later in the summer at the Arboretum on supposedly ozone-susceptible varieties of lilacs. The degree of injury seemed to relate to ambient ozone levels at the Arboretum. Greenhouse lilacs exposed to schronic low levels (0.06-8ppm) for 5 hrs/day for 5-8 weeks developed flecking and glazing symptoms. Typical leaf roll necrosis symptoms developed on *Syringia vulgaris* cv Marie Legraye, Miss Ellen Wilmot, and Primrose, but only bronzing occurred on cv Congo. This conformed data obtained the previous winter. A complicating factor may be what appears to be feeder root deterioration in the lilacs growing at the Arboretum. I suspect a nematode problem and we will look at this as soon as the ground thaws next spring.

Publications: 83/10 to 84/09
 DAMICONE, J.P., MANNING, W.J. and FEDER, W.A. 1984. Effects of ozone and *Fusarium oxysporum* alone and in combination on growth early maturing soybean lines. *Phytopathol.* 74 (7):843.
 COLLEY, D.R., MANNING, W.J. and FEDER, W.A. 1984. Differences in alfalfa cultivar sensitivity to ozone. *Phytopathol.* 74

(7):843.

66.002 CRIS0048013
EFFECTS OF ACID PRECIPITATION ON THE RHIZOSPHERE

ALEXANDER M; GRUNES D L; Agronomy; Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: 1931-20780-001-01S
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 01 SEP 82 to 31 AUG 85

Objectives: Determine the effect of simulated acid precipitation on microbial numbers and activities in the rhizosphere, emphasizing nitrogen transformations. To separate the effects of the two main contributors to acid rain, nitrous oxides and sulfur dioxide. Explain unobserved responses to acid rain in order to contribute to the effort to understand and predict the impacts of acid precipitation on the environment.

Approach: Grow alfalfa and wheat on an acid soil of low buffering capacity and exposed to acidified precipitation applied to foliage, soil only and foliage and soil; apply simulated rain to alfalfa on 3 soils varying in buffering capacity and fertility. Data collected for both experiments will include plant yield, dilution plate counts of bacteria and assays of microbial activities in the rhizosphere soil, including denitrification, ammonification, nitrification, and CO₂ evolution.

Progress: 83/01 to 83/12. Mycorrhizae of white pine and red oak were found to be 1984. to acid rain at levels that do not affect plant growth. Experiments simulating chronic exposure indicate that infection is reduced at pH levels Symposium. occurring in the northeastern U.S. At ambient loading rates, infection is affected only in infertile soils. The significance of these results for plant nutrition and stress tolerance, and the possibility of synergistic interactions with other pollutants are currently being studied. Nitrogen mineralization was decreased in 9 of 12 forest soils studied. Soils with low organic matter and low C:N ratios were most affected while N mineralization in soil with high C:N ratios was stimulated. Soil pH had no effect on the response, although liming soil reduced the sensitivity to acid rain. Thus, biological processes may be sensitive to acid rain in soils previously considered resistant because of high pH, although the mechanism by which acid rain affects mineralization is unknown. Also, this study and studies of N cycling in vegetated soils suggest that N leaching from soils may be enhanced by acid rain.

Publications: 83/01 to 83/12
 REICH, P., SCHOETTLE, A., STROO, H., TROIANO, J. and AMUNDSON, R. 1984. Effects of low concentrations of O₂, acid rain and soil type on net photosynthesis and mycorrhizal infection in northern red oak.

66.003* CRIS0090587
**GENETIC CHANGES ASSOCIATED WITH THE
 ACIDIFICATION OF A FOREST WATERSHED**

BRUSSARD P F; Ecology and Systematics Sec;
 Cornell University, Ithaca, NEW YORK 14853.
 Proj. No.: NYC-183567

Project Type: MCINTIRE-STENNIS

Agency ID: CSRS Period: 01 JUN 83 to 30 SEP 86

Objectives: *Daphnia middendorffiana* is a key organism in food chains in high altitude forest watersheds in the Colorado Rockies, and genetic diversity in this species consists solely of coexisting, noninterbreeding clones. Increasing acidification of these watersheds is occurring as a result of acid precipitation. This investigation will study the expected loss of clonal diversity which is likely to occur in *Daphnia middendorffiana* populations as acidification proceeds.

Approach: These studies will be conducted in the Mexican Cut/Galena Mountain Research Preserve and nearby areas in Pitkin and Gunnison Counties, Colorado. The patterns of physical, chemical, and biological change in this watershed resulting from increasing levels of acid precipitation have been documented at Mexican Cut since 1980. *Daphnia middendorffiana* populations will be sampled from Mexican Cut ponds throughout the icefree season, and their clonal composition will be determined by starch- and acrylamide-gel electrophoresis. The detailed ecological information available from the Mexican Cut watershed project will allow me to test the hypothesis that changes in clonal diversity in *D. middendorffiana* are related to changes in environmental parameters resulting from increased acidification.

Progress: 84/01 to 84/12. *Daphnia middendorffiana* populations were found to exist in 6 of the 17 ponds in the Mexican Cut watershed on the western slope of the Rocky Mountains in Colorado. Laboratory culture of individuals collected from these populations was attempted without success. Culture was then attempted by isolating individuals in containers suspended within their native ponds; this proved to be successful, and 25 clones from each of the 6 ponds were frozen for electrophoretic analysis. An enzyme screen for this species has already been completed at the Cornell Laboratory for Ecological and Evolutionary Genetics, and the 150 clones collected during the field season will be subjected to electro-phoretic analysis at 20 loci during the spring of 1985.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

66.004* CRIS0074748
**CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON
 AGRICULTURE, FORESTRY, SURFACE, WATERS, AND
 MATERIALS**

WEIDENSAUL T C; Environmental Studies Lab;
 Ohio Agric Res and Devlp Center, Wooster, OHIO
 44691.

Proj. No.: OH000627 Project Type: HATCH

Agency ID: CSRS Period: 02 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America and assess the effects of atmospheric deposition on the following: productivity of agricultural crops, forest trees, rangelands, wetlands, and soils and on the chemical composition of surface and ground waters.

Approach: Wet and dry atmospheric deposition samples are collected at weekly and bi-monthly intervals, respectively and will be analyzed for various components. Spatial and temporal trends in deposition will be determined via. data analyses of stored information from around the U.S. Studies will be conducted to determine the influence of natural soil solution and atmospheric acidification as well as field and laboratory studies to assess the impacts of atmospheric acidity on forest productivity and soil microorganism activity. Leachability of soils from Ohio, PA., NY, and Ontario will be studied re exposure to acid gases and simulated acidic deposition.

Progress: 84/01 to 84/12. Wet and dry deposition continue to be monitored at Caldwell and Wooster, Ohio. The total wet deposition of monitored materials at the two locations between Jan 1 and Dec 31, 1983 is recorded below. pH values are not normalized for total rainfall re hydrogen ion deposition.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

CM 67 PLANTS - NOT COMMODITY ORIENTED

67.001* CRIS0090116
**CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS
ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND
MATERIALS**

BOYD C E; Agricultural Exper. Station; Auburn
University, Auburn, ALABAMA 36830.
Proj. No.: ALA00587 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Small amounts of several types of surface soils will be confined in various kinds of containers in the laboratory. Rain water, representing different degrees of acidification, will be passed over, passed through, or agitated with the soils for different lengths of time. The changes of pH and alkalinity of the water will be measured. Ponds will be treated with hydrated lime and the residual effect of the lime in neutralizing acidity will be ascertained. The benefit of liming to fish and other aquatic life will be considered.

Progress: 84/01 to 84/12. Ponds were treated with sulfuric acid to produce different levels of alkalinity (three replications for each alkalinity value) and fish production was determined. All ponds were fertilized at same rate, but primary productivity decreased with decreasing alkalinity. The best fish production was achieved at 20 mg/l of alkalinity ($P < 0.05$). Production of sunfish did not differ significantly at alkalinity treatments of 1, 3, 5, and 8 mg/l.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

67.002 CRIS0087192
**CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND
EFFECTS ON LAND AND SURFACE WATERS**

TOPOL L E; Environ Monit & Serv Ctr; Rockwell
International, Newbury Park, CALIFORNIA 91320.
Proj. No.: CALW-RI-NC-141-1 Project Type: STATE
Agency ID: OCI Period: 01 OCT 81 to 30 SEP 85

Objectives: Establishing an Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Developing optimum procedures for collecting precipitation (regular timed sampling and event sampling) and dry particulate matter (open containers, air-filtration collectors, and biological collectors). Determining the stability of

certain constituents of precipitation during collection, transport and storage prior to analysis.

Approach: Network of 19 sites in 17 states in eastern and midwestern U.S. performs daily samplings. Each site has at least one HASL type collector and a weighing bucket rain gauge and measures sample amount, pH and conductivity. Chemical constituents of samples analyzed in lab. Data analysis to be performed.

67.003* CRIS0074466
**CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND
EFFECTS ON LAND AND SURFACE WATERS**

BURGY R H; MYRUP L O; Land, Air & Water
Resources; University of California, Davis,
CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-3619-RR Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establishing an Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Developing optimum procedures for collecting precipitation (regular timed sampling and event sampling) and dry particulate matter (open containers, air-filtration collectors and biological collectors). Determining the stability of certain constituents of precipitation during collection, transport and storage prior to analysis. Investigating the transport and transformations of atmospheric constituents. Organizing and coordinating research is the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition.

Approach: For all objectives listed, utilizing a network sampling station and specifications developed by the Regional Project, the data collection, processing analysis and interpretation will be adapted to project requirements. Special studies are to be devised in concert with project subcommittee coordination.

Progress: 79/09 to 83/09. The data acquisition site in the National Atmospheric Deposition Program has been operational since the Fall of 1979. During the first three years of operation only the rainfall season collections were made in the period of September through May. In 1982, the project operation was made to conform to the NADP standards and schedule with full seasonal data collection made weekly throughout the year. During the five years of records acquired at the station a trend is observable in the measured hydrogen ion concentration (pH) of sampled rainfall, tending to become more neutral with pH approaching 5.6. Occasional samples are measured with both higher and lower pH values. Improvement in the station operating procedures and in the handling and processing

both in field and laboratory may account for some reduction in the occurrence of low pH values. Other factors may include improved environmental conditions upwind from the site due to reduced emissions of NO(x) compounds for metropolitan areas and possibly to general shifts in weather phenomena transporting the precipitation products into the region. Based on the record of the site, a general conclusion may be indicated toward low acidic precipitation input in that area of California. The project has been replaced by Inter-Regional Project IR-7, effective October, 1983.

Publications: 79/09 to 83/09

NO PUBLICATIONS REPORTED THIS PERIOD.

67.004 CRIS0074559
THE EFFECTS OF EXISTING AND POTENTIAL AIR POLLUTION ON SAN JOAQUIN VALLEY CROPS

BREWER R F; Botany & Plant Sciences; University of California, Riverside, **CALIFORNIA** 92521.

Proj. No.: CA-R*-BPS-3631 Project Type: STATE
 Agency ID: SAES Period: 01 JAN 78 to 30 JUN 83

Objectives: Determine whether important San Joaquin Valley crops are subject to damage from current or potential levels of oxidant-type air pollution; establish several points on the ozone dose-response curves for representative crops so that valid assessments can be made of current and projected economic losses.

Approach: Field crop adaptable to open top field chamber growth conditions will be grown in atmospheres containing various proportions of ambient and filtered air, in some cases supplemented with electrically generated ozone. Vegetative and fruiting response will be measured and related to ozone dose.

Progress: 84/01 to 84/12. Cotton: For the second year SJ-2 and SC-1 Acala cotton varieties were exposed to 3 levels of SO(2) and 2 levels of ozone in specially designed open top plastic chambers. Responses to both pollutants were marked by moderate to severe infestation of the test plants by *Verticillium*, especially in the case of SJ-2 variety. Vert. resistant SC-1 produced approximately 7% less cotton when exposed to ambient oxidants and 10.6% less when exposed to .10 ppm SO(2) 6 hr/day, 4 da/wk. Thompson Seedless Grapes: A 3 yr study involving the effects of SO(2) and ambient ozone on Thompson seedless grapes was initiated in 1984. Sixteen large open top plastic chambers were placed over 10-yr-old mature vines. Each chamber, which measured 24 ft long, 10 ft wide and 10 ft high, enclosed 3 vines. Half of the chambers received filtered air and half ambient air. To half of each group of filtered or ambient chambers was added SO(2) gas in sufficient quantity to produce a concentration of 0.10 ppm by weight.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

67.005

CRIS0081295

MECHANISM OF INJURY TO PLANTS BY SMOG

HEATH R L; Botany & Plant Sciences; University of California, Riverside, **CALIFORNIA** 92521.
 Proj. No.: CA-R*-BPS-3943-H Project Type: HATCH
 Agency ID: CSRS Period: 16 APR 80 to 30 SEP 86

Objectives: Application of basic research information to the problem of ozone damage to field crops; studies to evaluate the role of leaf development and plant water potential in development of ozone injury; chemical studies using specific biochemicals known to react with ozone, including lipids, a-tocopherol, proteins; oxidant effects on photosynthesis and stomate behavior varying light, temperature, plant water potential; oxidant action on isolated chloroplasts and single cells, including *Chlorella*.

Approach: A broad integrated study on how growth conditions and water status affect air pollution damage to plants. Construction of a predictive model to allow specification of conditions to minimize damage to field plants. Field studies to follow in conjunction with campus members with relevant expertise.

Progress: 84/01 to 84/12. We have completed our studies of the oxidation products of unsaturated fatty acid by ozone in water solutions. The products, although not completely identified, were consistent with the Creigee Mechanism in polar organic solvents. Unfortunately, in water solutions, the products were more diverse and, being water soluble, were impossible to isolate for normal gas-liquid chromatography. Thus, we must conclude that the identification and quantitation of the ozone-induced products of unsaturated fatty acids from plants is impossible without much more research into lipid extraction. We have completed our initial studies on the transpiration and photosynthesis of Pinto bean plants (the control without ozone exposure) in order to ascertain the experimental variability. In completing these initial experiments we found that we had to upgrade our data handling capabilities by using certain softwares. The system is now operational and the final conclusion will be completed by next year.

Publications: 84/01 to 84/12

HEATH, R.L. 1984. Air pollution effects on biochemicals derived from metabolism: organic, fatty, and amino acids, In *Gas Air Pollutants and Plant Metabolism*, Eds. M. J. Kozioł, F. R. Whatley. Butterworths, London. pp.

HEATH, R.L. 1984. Decline in energy reserve of *Chlorella sorokiniana* upon exposure to ozone. *Plant Physiol.* 76:700-704.

67.006 CRIS0075984
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

WAINES J G; Botany & Plant Sciences;
 University of California, Riverside, CALIFORNIA 92521.
 Proj. No.: CA-R*-BPS-3670-RR Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors. To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: Conduct fumigation experiments, physiological experiments, screening experiments and yield trials as specified in the procedures section of Project NE-121.

Progress: 84/01 to 84/12. A field experiment was established to examine within cultivar variability for susceptibility to oxidant stipple injury from ambient ozone. Susceptible and tolerant cultivars of *Phaseolus vulgaris* were used in this experiment. Early indicators were that large within cv. variation exists. The experiment was terminated due to a large amount of insect damage, and to insufficient ambient ozone. Tolerant and susceptible cultivars of *P. lunatus* lima bean were selected.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

67.007 CRIS0080566
THE EFFECT OF ACID PRECIPITATION ON PLANT PHYSIOLOGY AND THE TRANSPIRATION PROCESS

MARLATT W E; MARLATT W E; Earth Resources;
 Colorado State University, Fort Collins,
 COLORADO 80523.
 Proj. No.: COL05308

Project Type: MCINTIRE-STENNIS
 Agency ID: CSRS Period: 01 NOV 79 to 30 SEP 84

Objectives: The major objective of the proposed investigation is to evaluate the capacity of precipitation quality to influence the water relations of plants. To accomplish this objective the proposed project will: Determine the ability of simulated "acid rain" solutions of varying chemical composition and pH to regulate transpiration rates and total water consumption in two species of plants differing in cuticular, stomatal and vascular system morphology. Two acids that are considered to be important anthropogenic air pollutants will be used at pH levels mimicing the range of average rainfall acidity in portions of northern Europe and the northeastern U.S. and near the extreme conditions that have been measured to date; determine the sensitivity of critical plant structures to "acid rain" impact; determine the relative importance of the interception and absorption pathways in atmospheric deposition effects.

Approach: The test species will be grown under greenhouse conditions and sprayed or irrigated with the acid treatment solutions. Water consumption will be monitored with an array of tensiometers. Measurement of the daily course of transpiration with a diffusive resistance porometer will be used in conjunction with stomatal function determinations to investigate changes in cuticular or stomatal resistance to water movement. Root system permeability will be examined at the end of the treatment period. Growth rate, phenological events, morphological changes and soil acidification will also be monitored.

Progress: 83/10 to 84/10. The greenhouse measurement program has been completed and the final report is in preparation. Preliminary findings indicate that the differences in water consumption between ponderosa pine seedlings sprayed or irrigated with H₂SO₄ and HNO₃ solutions at pH's of 2.5, 3.5 and 4.5 were not statistically significant from that of the control groups. This finding is in contrast to results of our previous studies. Small but perhaps important changes in cuticular wax structure were observed in the lowest pH treatment groups. The changes include a breakdown of wax microstructure with low pH spray (both acids) or under irrigation with H₂SO₄. These structural changes indicate that long-term exposure to acid droplets may produce changes in cuticular structure that could have ramifications for total water consumption. Some acid treatments appeared to increase total chlorophyll content over control groups - these included all H₂SO₄ spray treatments and most H₂SO₄ and HNO₃ irrigation treatments. Irrigation with H₂SO₄ at pH 2.5, however, produced a significant decrease in chlorophyll content. Other data (excised needle weight loss curves, diffusion porometry studies) are still being analyzed.

Publications: 83/10 to 84/10
 NO PUBLICATIONS REPORTED THIS PERIOD.

67.008* CRIS0077142
ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURAL AND FORESTED LAND AND SURFACE WATERS

GIBSON J H; Natural & Environmental Res;
 Colorado State University, Fort Collins,
 COLORADO 80523.
 Proj. No.: COL02014 Project Type: SPECIAL GRANT
 Agency ID: CSRS Period: 03 JUL 78 to 30 SEP 80

Objectives: Establish Atmospheric Deposition Network to determine spatial & temporal trends in supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter. Determine relative importance of precipitation & dry particulate matter. Develop optimum procedures. Determine stability of collection of precipitation constituents. Investigate transport & transformations. Organize & coordinate research in SAES, FS, & other institutions on the effects of atmospheric deposition on the productivity of agricultural

crops, forests, range, wet lands, & surface waters.

Approach: Provide coordination for development of a program nationally to meet objectives including organization of central analytical laboratory & data analysis management service.

Progress: 82/01 to 82/12. Funds made available by the North Central Region of the State Agricultural Experiment Station (NC-141) and the U.S. Department of Agricultural CSRS are combined to support the coordination, data management and publications for the NC-141-sponsored program in atmospheric deposition referred to as the National Atmospheric Deposition Program (NADP). This support has been primarily directed to the establishment and coordination of a national atmospheric deposition monitoring network. Additional support has been obtained from other Federal agencies including BLM, EPA, USGS, USFS and NOAA, and a number of sites are supported by state agencies and private corporations. Since the beginning of the program in 1978, this monitoring network has expanded to 108 operating sites across the country, including Alaska and American Samoa. In 1983, NADP will become the core of the National Trends Network (NTN) which is being established under the mandated National Acid Precipitation Assessment Plan, with the addition of approximately 40 monitoring sites anticipated by 1984. Data published by the program now includes eight volumes covering data from July of 1978 through December of 1980. In addition, the monitoring data is available on computer tape either from the Natural Resource Ecology Laboratory, Colorado State University, or from the Environmental Protection Agency Data Management System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM. 1982. NADP Instruction Manual: Site Operation. Beigelow, D.S. (Editor). Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO. 30 pp.

67.009 CRIS0074715
CHEMISTRY OF ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

GIBSON J H; Natural Resource Ecology Lab; Colorado State University, Fort Collins, COLORADO 80523.

Proj. No.: COL00206 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 87

Objectives: Establish and maintain a monitoring station at the CPER within the NADP (IR-7) Atmospheric Deposition Network. Determine spatial and temporal trends in the supply of beneficial nutrients and potential injurious substances in atmospheric deposition. Develop optimum procedures for collecting precipitation and dry particulate matter. Determine the stability of certain constituents of precipitation during collection, transport and storage prior to analysis.

Approach: Establish a collection site on the Central Plains Experimental Range of the USDA/ARS. Investigate appropriate collection procedures for dry deposition. Investigate differences of analytical results for samples analyzed on site and after transport to a central laboratory.

Progress: 83/10 to 84/10. The atmospheric deposition monitoring site on the Central Plains Experimental Range of the U.S. Department of Agriculture (Pawnee Site) represents an important component of the National Atmospheric Deposition Program (NADP) monitoring network - now a 175-station network operated under the direction of an interregional project of the State Agricultural Experiment Stations (Project IR-7). This site has been operational since April of 1979. While data from this site indicates pHs averaging around 5.6, levels of sulfate and nitrate demonstrate a substantial contribution to the sample acidity by anthropogenic sources. The reason that pHs do not range in the low 4s is because this potential acidity is modified by alkaline soil particulate matter which is washed out with the rain and dissolved in the precipitation samples. This site has been designated as an NTN site for the federal acid rain monitoring program operated by the NADP. Data from this site and other sited in the network are now providing important information for studies such as those associated with the U.S./Canadian Memorandum of Agreement and the development of U.S. policy for the control of acidic deposition. For the first time, atmospheric deposition patterns and acidity can now be evaluated for the entire North American continent. The National Atmospheric Deposition Program network is now the core of the National Trends Network (NTN) established under the National Acid Precipitation Assessment Plan (NAPAP).

Publications: 83/10 to 84/10

GIBSON, J.H. and BARON, J. 1984. Acidic deposition in the Rocky Mountain region. Proceedings of Sixth High Altitude Revegetation Workshop. In Press.

67.010* CRIS0089822
CHEMISTRY OF ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

GIBSON J H; Natural Resource Ecology Lab; Colorado State University, Fort Collins, COLORADO 80523.

Proj. No.: COL00223 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife, and fish; c) the chemical composition of surface and ground waters; and d) atmospheric visibility and the corrosion of

metals, masonry.

Approach: Provide coordination to further develop and maintain the National Atmospheric Deposition Program (NADP) chemical deposition network as well as the NAPAP National Trends Network (NTN).

Progress: 83/01 to 83/12. This project furnished administrative support for research carried on under the IR-7 interregional research project goals stated above.

Publications: 83/01 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

67.011* CRIS0081176
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

GIBSON J H; Office of The Director; Colorado State University, Fort Collins, COLORADO 80523.

Proj. No.: COL00223; Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish Atmospheric Deposition Network to determine spatial and temporal trends in supply of beneficial nutrient elements and potentially injurious substances in precipitation & dry particulate matter. Determine relative importance of precipitation & dry particulate matter. Develop optimum procedures. Determine stability of collection or precipitation constituents. Investigate transport & transformations. Organize and coordinate research in SAES, FS & other institutions on the effects of atmospheric deposition on the productivity of agricultural crops, forests, range, wet lands & surface waters.

Approach: A program coordinator's office will be maintained to provide support for the NC-141 regional research project including project coordination, travel, special analyses and other project activities as needed by the regional research project. (This is to cover the RRF Off-the-Top Trust Fund to NC-141).

Progress: 82/01 to 82/12. Funds made available by the North Central Region of the State Agricultural Experiment Station (NC-141) and the U.S. Department of Agricultural CSRS are combined to support the coordination, data management and publications for the NC-141-sponsored program in atmospheric deposition referred to as the National Atmospheric Deposition Program (NADP). This support has been primarily directed to the establishment and coordination of a national atmospheric deposition monitoring network. Additional support has been obtained from other Federal agencies including BLM, EPA, USGS, USFS and NOAA, and a number of sites are supported by state agencies and private corporations. Since the beginning of the program in 1978, this monitoring network has expanded to 108 operating sites across the country, including Alaska and American Samoa. In 1983, NADP will become the core of the National Trends Network (NTN) which is being established under the

mandated National Acid Precipitation Assessment Plan, with the addition of approximately 40 monitoring sites anticipated by 1984. Data published by the program now includes eight volumes covering data from July of 1978 through December of 1980. In addition, the monitoring data is available on computer tape either from the National Resource Ecology Laboratory, Colorado State University, or from the Environmental Protection Agency Data Management System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12
NO PUBLICATIONS REPORTED THIS PERIOD.

67.012 CRIS0012552
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY IN THE NORTHEAST

CURTIS C R; CURTIS C R; SASSER M; Plant Science; University of Delaware, Newark, DELAWARE 19711.

Proj. No.: DELO0125; Project Type: HATCH
Agency ID: CSRS Period: 01 JUL 65 to 30 SEP 83

Objectives: Determine physiological, biochemical and morphological mechanisms of susceptibility and resistance of plant cultivars to air pollutants and determine whether of susceptibility and resistance of plant cultivars to air pollutants and determine whether these are affected by interactions with biotic factors in the environment. Identify the genetic mechanism of resistance of plant cultivars to air pollutants.

Approach: Leaves of ozone susceptible and resistant cultivars of watermelons and white potatoes will be examined for ozone injury following induced water congestion and subsequent ozone exposure. Relationships between leaf anatomy, leaf morphology, occurrence of water congestion and degree of ozone susceptibility will be determined. Genetic mechanisms of ozone resistance as related to water congestion will be determined by the use of resistant and susceptible lines. A study of isoenzyme profiles from selected plant species will be initiated to determine biochemical interrelationships between air pollution susceptible and resistant cultivars. Isoenzymes will be separated by disk-gel electrophoresis or isoelectric focusing procedures and quantitated by densitometric gel scanning. The electrophoretic profiles will be used as basis for evaluation of potential marker isoenzymes for genetic studies.

Progress: 83/01 to 83/12. During 1983 the Delaware soybean variety trials were monitored for evidence of photochemical oxidant injury. A number of diseases were noted in the Georgetown, Delaware field evaluations but none could be associated with atmospheric oxidants. The summer months usually exhibit an increase in photochemical oxidants dependent on meteorological conditions. This increase was detected in the 1983 growing season but the magnitude of atmospheric oxidant concentrations were far below those required for symptom expression. In a separate study on abiotic factors, the effects of simulated acidic

deposition on soil systems was examined. Leachates were collected from three Delaware soil types treated with simulated acidic rain at pH 2.5, 3.4, 4.8 and 5.6. In all soils and pH's the quantities of elemental release were $\text{Ca} > \text{K} > \text{Mg} > \text{Na}$. The amount of heavy metals and Si release were low. The highest Al release rates occurred at pH 2.5 in the soil type with the lowest clay and organic matter content. This soil type also had the poorest buffering capacity. Anionic release was evaluated and found to be negligible.

Publications: 83/01 to 83/12
None.

67.013 CRIS0048820
AIR POLLUTION AND IMPLICATIONS FOR AGRICULTURAL PRODUCTIVITY AND ENVIRONMENTAL QUALITY

SCHAUB J; BARSE J; USDA Economic Research Service, Washington, DISTRICT OF COLUMBIA 20250.
Proj. No.: NRED-PRS-4736 Project Type: INHOUSE
Agency ID: ERS Period: 01 OCT 82 to 30 DEC 83

Objectives: Appraise the effects of air contamination from a variety of sources on agricultural output and environmental quality.

Approach: Survey literature describing physical effects on crops (plant growth and crop yield) from air pollution and acid rain. Also survey literature describing calculations of economic losses resulting from adverse effects of the above pollutants on crops. Evaluate existing methodologies for loss calculation and develop and evaluate alternative methodologies, as appropriate.

Progress: 82/10 to 83/09. Literature describing physical, biological, and economic effects on crops, soils, and forests of acid rain and air pollutants has been surveyed. However, because this body of literature is extensive, the survey is not yet complete, although a first draft of an annotated bibliography has been prepared. In addition, existing methodologies for estimating economic losses to agriculture from air pollution and acid rain also have been surveyed. Tentative conclusions have been reached as to the methodology to be used in future months to make economic crop loss assessments.

Publications: 82/10 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

67.014 CRIS0072631
SULFUR DIOXIDE, AIR QUALITY AND FLORIDA VEGETATION

WOLTZ S S; HOWE T K; Agr Res & Ed Cntr; University of Florida Research & Education Cntr, Bradenton, FLORIDA 33508.
Proj. No.: FLA-BRA-01834 Project Type: STATE
Agency ID: SAES Period: 04 APR 77 to 31 DEC 83

Objectives: Determine the effect of SO_2 on growth, yield and quality of produce of agricultural plants; determine the symptomatology of selected weed and non-agricultural plant species as guides to the occurrence of SO_2 air pollution evaluate other air pollutants as modifiers of the effects of SO_2 and as contributors to the total damage and provide information and methodology to facilitate improvements in the general environment as well as agricultural field regimes.

Approach: A survey will be made of SO_2 air pollution effects on crop, ornamental and weed plant species in central Florida. Controlled greenhouse fumigation will be used to categorize plants into classes of low, medium or high susceptibility to SO_2 fumigation effects. Duration-level of exposure studies will determine the effects of duration and level in total exposure and interaction effects of other pollutants will be explored in combination with SO_2 .

Progress: 83/01 to 83/12. Seedlings suitable for transplanting were fumigated with fluoride first at 5 ppb then at 10 ppb to develop symptoms. 'Walter' tomato had interveinal chlorosis of the upper leaves suggesting that fluoride may have interfered with iron and/or manganese nutrition. 'Red Flash' petunia had a marginal purpling of flowers. 'Janie Yellow' marigold flowers were unaffected but leaves had randomly located scorch spots. 'Snowball X' cauliflower and 'Catskill' brussel sprouts had marginal chlorosis and a marginal purpling of the leaves. 'Dasher' zinnia developed leaf tip scorch of the older leaves; growth of upper leaves was very much limited in size. 'Red Cherry' tomato had severe marginal leaf scorch. 'Crimson Sweet' watermelon displayed a mild general leaf chlorosis. 'Seminole' cantaloupe had a marginal leaf chlorosis. 'Fantastic Pink' zinnia developed severe leaf scorch between the veins. 'Walter' tomato developed slight interveinal leaf scorch while 'Red Cherry' developed more of a random leaf spotting and flecking. 'Crimson Sweet' watermelon and 'Seminole' cantaloupe exhibited no symptoms of sulfur dioxide injury. 'Red Flash' petunia exhibited the typical sulfur dioxide injury symptoms of laminar scorch. 'Janie Yellow' marigold developed random leaf scorch spots involving only limited leaf area. 'Snowball X' cauliflower and 'Catskills' brussel sprouts developed a water-soaking injury visible from the back of the leaves. 'Dasher' zinnia exhibited much less damage than 'Fantastic Pink'.

Publications: 83/01 to 83/12
WOLTZ, S.S. 1983. Symptomology and sensitivity ratings of ornamental and vegetable seedlings to injury by sulfur dioxide and hydrofluoric acid fumigation. Bradenton AREC Res. Rept. BRA1983-25.

67.015* CRIS0084233
NITROGEN MANAGEMENT FOR GRAIN CROPS ON MEDIUM ACID SOILS

GOODROAD L L; Agronomy; Georgia Agric Expt Station, Experiment, **GEORGIA** 30212.
 Proj. No.: GE001305 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUL 81 to 30 JUN 86

Objectives: To evaluate precisely defined N rates from various sources, for maximizing feed-grain production under acid versus mildly acid soil stress conditions; to compare N efficiency among genotypes (hybrids); study the feasibility of utilizing nitrification inhibitors and controlled release materials to maximize N use efficiency; and evaluate the contribution of residual soil N for production in cropping sequences.

Approach: In order to assess treatment effects under natural environments, field plots will be utilized to attain the objectives of the study. Nitrogen balances will be attempted by soil N determinations, crop utilization, soil residues and N losses. Narrow increments of N from selected sources will be evaluated for efficient feed grain production at selected soil pH levels. Selected tolerant genotypes which have been developed for acid soil stress conditions will be compared for N use efficiency based on production levels, N uptake and protein levels. Nitrogen sources, with and without nitrification inhibitors, will be evaluated for selected species. Selected sites will be evaluated for residual N contributions to production of subsequent crops. Long-term rotations, including legumes such as soybeans, will be evaluated for N efficiency.

Progress: 84/01 to 84/12. Nitrogen rate and time of application studies have been established for winter wheat, sorghum, fescue and ratoon sorghum. Initial results indicate that double-cropped winter wheat (cv. Stacy) yields increased with N rates to 100 kg/ha following soybeans. An additional 30 kg N/ha at flowering (130 kg N/ha total) produced the highest yields for wheat following sorghum. In 1984, there was no increase in yields from split application of N at the 100 kg N/ha rate. Early growth of Triumph fescue was increased by N fertilizer compared to Kentucky 31 fescue. Studies in coastal plain soils have identified sulfur deficiencies which limit yields of winter wheat in sandy soils and soils with only shallow tillage. Seven corn hybrids commercially available in the southeastern U. S. were grown in field plots at three soil pH levels (4.8, 5.5, and 6.6) and four nitrogen (N) fertilizer rates (0, 80, 160, and 320 kg N/ha). Nitrogen efficiency parameters, grain yield/N supply (YE), total N uptake/N supply (UP), grain yield/total N uptake (UE), and grain yield/N uptake after silking (TE), were calculated. Grain yields were highest at the 160 kg N/ha rate, and there was a significant interaction between pH and variety effects on grain yields. The treatments having significant effects on N efficiency parameters included N supply on YE; N supply, variety, and variety x N supply on UP; and N supply and variety on UE.

Publications: 84/01 to 84/12

- GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide production in aerobic soils and under varying pH temperature and water content. *Soil Biol. and Biochem.* 16:39-43.
 GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide emissions from soils during thawing. *Can. J. Soil Sci.* 64: 187-194.
 GOODROAD, L.L. and KEENEY, D.R. 1984. Nitrous oxide emissions from forest, marsh and prairie ecosystems. *J. Envir. Qual.* 13:448-452.
 GOODROAD, L.L., KEENEY, D.R., and PETERSON, L.A. 1984. Nitrous oxide emissions from agricultural soils in Wisconsin. *J. Envir. Qual.* 13:557-561.

67.016* CRIS0074176
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE-WATERS

WALKER J T; Plant Pathology; Georgia Agric Expt Station, Experiment, **GEORGIA** 30212.
 Proj. No.: GE001249 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 30 JAN 83

Objectives: Establishing an atmospheric deposition network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Determining the relative importance and contribution of precipitation, dry particulate matter, aerosols, and gases to the total atmospheric deposition in various states and regions in the United States. Organizing research in the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters; etc.

Approach: Establish a collector of the wet/dry type (Volchok and Graveson) at an approved collection site and ship samples on scheduled basis to a central analytical laboratory for analysis. Determine the contribution and importance of these depositions to the state and region in terms of agricultural productivity (Agronomic crops) and effects on vegetation (trees, shrubs, or turf) in the rural and urban environments, specifically in terms of diseases and contribution to minor element requirements.

Progress: 77/12 to 83/01. Using the protocol of the NADP guidelines, an Aerochem Metric Precipitation Collector (Model 201) was installed in the Georgia piedmont in October, 1978. A recording rain gauge, wind vane-anemometer, and particulate sampler was operated at the site. Ozone levels were monitored elsewhere. Precipitation samples were analyzed by the Central Analytical Laboratory. Particulates (TSP) were determined on a filter exposed for 24 h every 6 days. The effects of acidified water on a variety of plants under growth chamber, greenhouse, and field conditions were determined. The effect of aqueous solutions at different pHs on

subsequent seed germination was studied. Over the 1979-81 period, the highest ionic constituent in rain was sulfate with an average of 2.6-3.5 mg/1/yr. followed by nitrate with 1.0 to 1.3 mg./1. The 3-yr. average for 9 ions in mg/1, was: Ca 0.24, Mg 0.13, KO.18, Na 0.45, NH(4) 0.33, NO(3) 1.2, Cl 0.46, SO(4) 2.99, PO(4) 0.06. The lowest average pH occurred in the 2nd and 3rd calendar quarter, with values ranging from a low of 4.12 to high of 4.96. Average TSPs for 1979, 1980, and 1981, were 37.2, 38.7, and 46.7 mg./m³, respectively. Ozone averaged 3.6 ppm. Lead averaged .052 to .073 mg./m³ annually. Some plant species and cvs were injured by acidic mists at pH 1.8, but few plants were affected by pH 2.6 sprays. Grass seed germination was decreased by pH 2.6 solutions, but alfalfa, corn and cucumber were unaffected. Germination of some soybean cvs was reduced at pH 2.6.

Publications: 77/12 to 83/01

NO PUBLICATIONS REPORTED THIS PERIOD.

67.017* CRIS0075841 CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

MCFEE W W; PAW-U K T; Agronomy; Purdue University, West Lafayette, INDIANA 47907.
Proj. No.: IND050045-A Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 82

Objectives: Determine spatial and temporal trends in supply of beneficial and injurious substances in precipitation and dry particulate matter deposited in various regions of the US. Determine contribution of precipitation, dry particulate matter, aerosols, and gases to atmospheric deposition in various regions in the US. Develop optimum procedures for collecting precipitation and dry particulate matter. Determine effects of atmospheric deposition on productivity and host-parasite relationships of crops and forests.

Approach: Samples of precipitation and dry particulate matter will be collected weekly and analyzed for SO(4), NO(3), PO(4), Cl, NH(4), K, Na, Ca, Mg, pH, total and free acidity, and electrical conductivity. Measurements will be made of the input of nutrients from the atmosphere to various crops and toxic effects of precipitation constituents on crop plants and forest trees.

Progress: 82/01 to 82/12. Equipment to collect atmospheric deposition was installed at the Agronomy Farm, West Lafayette, IN, and became operational in July. Additional equipment is on hand for establishment of a station in southern Indiana. Wet deposition measured in weekly samples in the period, July-September 1982, had a mean pH of 4.1-4.2 at the West Lafayette location. This monitoring will continue as a part of Inerregional Project, IR-7. A critical review of the literature on effects of acidic deposition of soils is being prepared for inclusion in a document for EPA.

Publications: 82/01 to 82/12

MCFEE, W.W. and CRONAN, C.S. 1982. The Action of Wet and Dry Deposition Components of Acid Precipitation on Litter and Soil. In: D'Itri (ed.). Effects of Acid Precipitation on Ecological Systems. Ann Arbor Science, Ann Arbor, MI.

MCFEE, W.W. 1982. Sensitivity Ratings of Soils to Acid Deposition: A Review. In Arthur, M.F., and Wagner, C.K. Response of Agricultural Soils to Acid Deposition. Electric Power Research Institute, EA 2508, Palo Alto, CA.

GLASS, N.R. ARNOLD, D.E., GALLOWAY, J.N., HENDREY, G.R., LEET, J.J., MCFEE, W.W., NORTON, S.A., POWERS, C.F., RAMBO, D.L. and SCHOFIELD, C.L. 1982. Effects of Acid Precipitation. Environ. Sci. Techn. 16:162A-169A.

67.018* CRIS0089884 CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

MCFEE W W; PAW-U K T; Agronomy; Purdue University, West Lafayette, INDIANA 47907.
Proj. No.: IND050045A Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, rangelands, wetlands and soils.

Approach: We will continue to operate one site at the Agronomy Farm to measure atmospheric deposition and plan to initiate a site in southern Indiana. We will develop and test models of the short and intermediate range transport of atmospheric, point source pollutants. Laboratory experiments on the effects of acidic deposition on the chemical and physical properties of soil will be used to examine the movement of metal in response to acidity and to evaluate soil sensitivity rating systems.

Progress: 84/01 to 84/12. Data from 2 years of studying the atmospheric deposition of acidic and nutrient materials in the precipitation at the Purdue Agronomy Farm were summarized and prepared for publication. The mean volume-weighted pH based on laboratory analyses is 4.36. The unweighted mean weekly sample pH based on measurements taken before shipment of the samples is 4.15. There is a tendency for sulfate and H ion concentration to be higher in the growing season. The mean annual S and N deposition in the precipitation based on two year's data is 8.4 kg/ha and 6.2 kg/ha respectively. Sampling and analysis of the precipitation of the Southwest Purdue Agricultural Center at Vincennes was begun in August, 1984 to support the studies of air pollution effects on melons being conducted there.

Publications: 84/01 to 84/12

MCREE, W.W., ADAMS, F., CRONAN, C.S.,
 FIRESTONE, M.K., FOY, C.D., HARTER, R.D.
 and JOHNSON, D.W. 1984. The acidic
 deposition phenomenon and its effects:
 Chapter E2, Effects on soil systems.
 EPA-600/8-83-016 F. pp. 2-1 through 2-57.

67.019* CRIS0087502
BOUNDARY LAYER PHENOMENA & ACIDIC PRECIPITATION

PAW-U K T; Agronomy; Purdue University, West
 Lafayette, **INDIANA** 47907.
 Proj. No.: INDO50079 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUN 82 to 01 MAY 84

Objectives: To analyze and identify the importance of air flow in the vicinity of vegetation, and its interaction with the air flow in the atmospheric boundary layer. To analyze and identify the nature of the interaction between biota and the atmospheric boundary layer, and to identify key variables in the interaction.

Approach: Theoretical, field, and laboratory research will be conducted to determine the patterns and turbulent nature of clean or particle-laden air flow in the vicinity of vegetative elements. The patterns will be analyzed in terms of interactions between the biota and atmosphere; the transport of such material as sulfur compounds and their effect on acidic precipitation will be of special interest.

Progress: 83/01 to 83/12. The estimation of leaf diffusive resistances as a function of temperatures of coated and uncoated leaves was modeled; it was found estimations with the energy budget method were as accurate as porometrically derived values. Theoretical work was also done on the occurrence of equal leaf and air temperatures. The nature of pollen trajectories in the vicinity of ovulate cones was examined with the aid of videotape analysis, and it was determined that many factors increase net deposition of pollen grains on the ovulate cones. It was determined, however, that the von Karman vortex formation behind ovulate cones was probably not a significant phenomenon in terms of evolutionary pressure. Acidic precipitation studies continued at Purdue. Very low pH values were measured for some precipitation (less than 3.5), but no values higher than 5.6 were reported. Theoretical work showed that under certain conditions, a single power plant of the 60 mW size could cause significant acidic precipitation from over 100 to 300 km downwind. The model used was not valid for greater distances, although it is possible the contribution would also be significant at those locations.

Publications: 83/01 to 83/12

PAW U, K. T. 1984. A theoretical basis for the leaf equivalence point temperature. Accepted by Agricultural Meteorology.
 ANDRESEN, J. and PAW U, K. T. 1984. Modeling of SO₂ emissions and acidic precipitation at mesoscale distances. Accepted by

Electric Utilities Research Conference, Chicago, 1984.

NIKLAS, K. J. and PAW U, K. T. 1983. Conifer ovulate cone morphology: implications on pollen impact patterns. Amer. J. Botany 70:568-577.

PAW U, K. T. 1983. Rebound of particles from natural surfaces. J. Colloid Interface Science. 93:442-452.

PAW U, K. T. 1983. A universal model for entrainment processes. Accepted by Proceedings, 4th Conference on Precipitation Scavenging Dry Deposition and Resuspension, 29 Nov.-Dec. 1982. (Refereed proceedings).

67.020* CRIS0089414
CHEMISTRY OF ATMOSPHERIC DEPOSITION EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

GROVE J H; Agronomy; University of Kentucky, Lexington, **KENTUCKY** 40506.
 Proj. No.: KY00244 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America: to assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, range lands, and soils; the chemical composition of surface and ground waters.

Approach: Wet and dry deposition will be collected, characterized, and chemical analysis of entrained water soluble and insoluble and chemical analysis of entrained water soluble and insoluble substances completed. The role of acid deposition in acidification of managed and unmanaged soil profiles will be studied with saturation extract and undisturbed core techniques. Use of ⁷AL nuclear magnetic resonance spectroscopy is proposed to characterize the soluble aluminum chemistry of soils under study.

Progress: 84/01 to 84/12. Studies on basic soil acidification processes and solution Al chemistry were continued. Soil acidification control via lime addition was monitored under continuous corn production at two levels of residue management intensity. Major reductions in strong acidity were uniformly distributed in the moldboard plow horizon of the plots under conventional residue management. The acidity control was confined to the surface 5 cm of soil in the no-tillage plots. Control of strongly developed acidity is apparently very difficult in reduced tillage system as the lime reaction seems less mobile than the acid products of nitrification. The accumulation of organic matter at the surface of the no-till soil appears to impede mobility of the lime reaction as well. Corn productivity has yet to be restored in the extremely acid no-till plots.

Publications: 84/01 to 84/12

GROVE, J.H., BLEVINS, R.L. and BERTSCH, P.M.
1984. Preliminary indications on the
control of surface soil acidification in
no-tillage corn production with suspended
lime. Proc. Sym. Fluid Fert. Found. p.
24-30.

67.021* CRIS0090945
STRESS PHYSIOLOGY OF WOODY PLANTS

KIMMERER T W; Forestry; University of
Kentucky, Lexington, KENTUCKY 40506.
Proj. No.: KY00631
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 03 AUG 83 to 30 JUN 88

Objectives: To develop a bioassay for plant stress based on emissions of acetaldehyde and ethanol, determine whether induction of ethanol biosynthesis by air pollution stress is unique to woody plants, determine the relationship between ethane production and ethanol biosynthesis, and examine the biochemical mechanisms of aerobic ethanol synthesis in stressed plants.

Approach: Plants will be exposed to SO₂, O₃ and a number of other abiotic and biotic stresses in controlled environment chambers. Ethanol and acetaldehyde emissions, along with ethylene and ethane production, will be assayed by gas chromatography. A number of woody and herbaceous plant species will be tested. A bioassay for plant stress, based on emissions of volatile hydrocarbons, will be developed for woody and herbaceous plants, tested and validated in the field. Enzyme and substrate assays will be used to examine the role of pyruvate in aerobic ethanol synthesis.

Progress: 83/08 to 83/12. Biochemical indicators of environmental stress in woody plants are being developed. The goal is to be able to differentiate among several kinds of stress, e.g. water deficit and ozone stress. Trees exposed to ozone stress produce ethanol and acetaldehyde under aerobic conditions. The key enzymes in acetaldehyde and ethanol biosynthesis, pyruvate decarboxylase (E.C. 4.1.1.1) and alcohol dehydrogenase (E.C. 1.1.1.1) have been isolated from soybean cottonwood leaves by affinity chromatography. Following several kinds of stress, including O₃, drought, spider mite injury and heat shock, alcohol dehydrogenase activity increases in cottonwood but not in soybean. Only following O₃ does cottonwood synthesize ethanol. Alcohol dehydrogenase may have other catalytic roles in woody plants. Under anaerobic conditions, previously stressed trees produce ethanol within 1 hour, while in previously unstressed trees, a lag of 2-4 hours occurs.

Publications: 83/08 to 83/12
NO PUBLICATIONS REPORTED THIS PERIOD.

67.022* CRIS0088960
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

FEAGLEY S E; Agronomy; Louisiana State University, Baton Rouge, LOUISIANA 70803.
Proj. No.: LAB02307 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temperal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the chemical composition of surface and ground waters.

Approach: These objectives will be achieved by further developing and maintaining the NC-141/NADP atmospheric chemical deposition and related local networks. Estimates of atmospheric sources of nutrients for growth of agricultural crops and forest trees will be taken. Contribution of atmospheric sulfur to growth of cultivated and non-cultivated crops. Foliar uptake of nutrient and toxic metals by forest trees and orchard, field, forage and vegetable crops. Identification of regions that are sensitive and soil factors contributing to sensitivity to acid precipitation. Influence of precipitation chemistry on mineral weathering, colloid chemistry, clay development, and suspension potential of soils. Long-term and short-term changes in atmospheric deposition and mobilization of heavy metals.

Progress: 84/01 to 84/12. The total amount of rainfall at Homer, New Iberia and Franklinton through 12/19/84 was 54.93, 60.36 and 56.12 inches, respectively. The range in pH for each site respectively was 4.95 to 4.07, 5.56 to 4.20 and 5.66 to 4.01. The range in EC was 25.7 to 3.9, 40.0 to 4.2 and 40.0 to 8.5 μ S/cm. (+) Other parameters being monitored are NO₃, PO₄, SO₄, Cl, Ca, Mg, K, Na and NH₄. Four ponds are being monitored weekly by taking surface samples. All parameters mentioned above are being done on the samples as well as temperature. A lake sampler is being tested to sample the lake from the shore at various depths.

Publications: 84/01 to 84/12
FEAGLEY, S.E. and CREMERS, R.B. 1984. Acid rain and its accumulation: A problem in Louisiana? La. Agric. 27:4, 5 and 24.

67.023* CRIS0086840
ATMOSPHERIC DEPOSITION OF ACID RAIN AND MINERAL ELEMENTS IN LOUISIANA

JONES J P; FEAGLEY S E; Agronomy; Louisiana State University, Baton Rouge, LOUISIANA 70803.
Proj. No.: LAB02249 Project Type: HATCH
Agency ID: CSRS Period: 01 MAR 82 to 04 JAN 83

Objectives: Establish atmospheric deposition collection sites for wet and dry precipitation in selected areas and provide appropriate data

in cooperation with the National Atmospheric Deposition Program (NC-141).

Approach: Monitor precipitation from the atmosphere in Louisiana to include: pH, wet and dry deposition of sulfur, nitrogen and heavy metals. Determine the effect of acid precipitation and the deposition of sulfur and heavy metals on agricultural crops and livestock.

Progress: 82/03 to 83/01. Project H2249 on Nc0141 is being terminated and replaced by H2307 on IR-7 project. Three NADP sites were established in Louisiana. These were located at Homer, Iberia and Franklinton. The Homer and Iberia sites were put into operation on November 16, 1982. Franklinton will be started at a later date because of electrical difficulties. The pH values ranged from 4.78 to 5.18 at Homer and 4.50 to 5.76 at Iberia. The precipitation weighted averages from 11/16/82 to 1/4/83 were 5.01 at Homer and 5.44 at Iberia. The E.C. values ranged from 1.2 to 13.5 umhos./cm. at Homer and 3.8 to 15.2 umhos./cm. at Iberia. The precipitation weighted averages were 8.0 and 5.5 umhos./cm. at Homer and Iberia, respectively.

Publications: 82/03 to 83/01

NO PUBLICATIONS REPORTED THIS PERIOD.

67.024

CRIS0019461

ACTION OF AIR POLLUTION ON PLANTS

BENNETT J H; USDA Agricultural Research Service, Beltsville, MARYLAND 20705.
Proj. No.: 1209-20172-006-00D

Project Type: INHOUSE

Agency ID: ARS Period: 27 MAY 68 to 30 MAR 85

Objectives: Determine the physiological bases of plant tolerance to oxidant stress, sulfur- and nitrogen-oxides, and ethylene through pursuing research leads into promising physiological and chemical controls.

Approach: Sensitive and tolerant crop varieties will be examined in Physiological Activity and Diagnostic Chambers (PhAcDC) under standardized mass- and energy-budget regimes. Relative susceptibilities of the tissues will be based on measured phytotoxic doses absorbed. The extent recently developed antiozonant chemicals transform ozone-sensitive plants into tolerant ones will be determined. The action of inducible plant oxidoreductase enzymes in preventing injury and aging will be appraised. Ethylene evolution from ozone-stressed tissues will be measured. Ethylene phytotoxicity will be manipulated with antioxidants and AgNO₃. Quality of partitioned phytosynthates will be evaluated. Synergistic effects shown by SO₂ + NO₂ combinations in suppressing phytosynthesis will be studied and their inferred action on ferredoxin will be tested.

Progress: 83/01 to 83/12. Effects of light-, high temperature-, water- and oxidant-stresses showed that threshold cotyledonary reserves or adequate photosynthate availability were required to permit proton and reductant efflux

functions essential to regulate ⁹⁹Fe uptake and utilization. Phosphate and nitrate imbalances led to chloroplast degradation when the plant carbohydrate reserves were low. Root-shoot functional integrity could be reestablished using (hollow) stem IV infusion techniques to correct nutrient and hormone problems in inefficient snap bean (F(1)) hybrids. High temperature and P/N stresses leading to visible injury mimic Fe-deficiency symptoms in leaves. Chronic oxidant stress mimics aging and contributed to assimilate deficiency stress. Cell and tissue culture techniques were used to study and characterize the differential ozone (O₃) tolerance in tobacco. Foliar O₃ tolerance was related to leaf ascorbic acid (AA) concentrations in O₃-susceptible vs O₃-tolerant soybean and snap bean cultivars had higher levels of AA than the sensitive cultivars. Young trifoliate leaves were tolerant to O₃ and had higher AA concentrations than newly expanded leaves. A threshold concentration was required for good protection. O₃ stress was found to induce the production and accumulation of AA in O₃-treated leaves.

Publications: 83/01 to 83/12

BENNETT, J.H., LEE, E.H. and HEGGESTAD, H.E. 1984. Biochemical aspects of ozone and oxyradicals: Superoxide dismutase. In F.R. Whatley and M. Kozioł (eds.) Gaseous Air Pollutants and Plant Metabolism. pp. 413-424. Butterworths Press.

BENNETT, J.H., KRIZEK, D.T., WERGIN, W.P., FLEMING, A.L. and WYSE, R. 1983. Chlorosis and regreening in terminal leaves of growth chamber plants grown under LPS light. Proc. Second Inter. Symp. Iron Nutr. and Interact. in Plants.

HEGGESTAD, H.E., BENNETT, J.H. and GISH, T.J. 1983. Effects of air pollutants and soil moisture stress interactions on soybean yields. Photopath. 73(6):966.

HEGGESTAD, H.E., GISH, T.J., BENNETT, J.H. and DOUGLASS, L.W. 1983. Interactive effects of O₃, SO₂ and soil moisture stress on soybeans. Agron. Abstr. pp. 32-33.

BENNETT, J.H., KRIZEK, D.T., WERGIN, W.P., FLEMING, A.L., MIRECKI, R.M. and WYSE, R.E. 1984. Physiological and ultrastructural changes in the chloroplast of snap beans grown under LPS lamps during chlorosis and regreening.

67.025

CRIS0019460

ACTION OF AIR POLLUTANTS ON PLANTS AND METHODS OF DAMAGE CONTROL ESPECIALLY THROUGH RESISTANCE

HEGGESTAD H E; Plant Stress Lab; USDA Agricultural Research Service, Beltsville, MARYLAND 20705.

Proj. No.: 1209-20172-005-00D

Project Type: INHOUSE

Agency ID: ARS Period: 10 MAY 68 to 31 MAR 85

Objectives: Determine the nature and extent of the seasonal cumulative (chronic) effects of major gaseous pollutants on growth, yields and quality of agronomic and horticultural crops. Develop technology for minimizing and

preventing damage.

Approach: A spectrum of commonly grown cultivars of important species classified most vulnerable to chronic air pollution injury will be exposed to low levels of pollutants from the seedling stage to maturity to assess effects on plant growth and productivity. Comparisons will be made between greenhouse and field-grown plants to better relate data from greenhouse and field situations. Experiments will involve use of open-top field chambers, the exclusion of ambient pollutants with filters, the addition of chronic levels of pollutants such as sulfur dioxide to chambers, and the use of chemical protectants without chambers. Cooperative studies with other scientists are anticipated to identify cultivars tolerant to the pollutants, to determine heritability of resistance, and to assess the nature of resistance using cultivars having extreme differences in tolerance to specific pollutants.

Progress: 83/01 to 83/12. A soil moisture-ozone interaction experiment was conducted with soybeans (*Glycine max.*). Cultivars Williams and Corsoy were exposed to increasing doses of O₃ in open-top field chambers from flowering to seed maturity. Treatments were ambient air (no chamber), charcoal filtered air (CF), nonfiltered air (NF), NF + 0.03, + 0.06, + 0.09 ppm O₃ for 7 hours/day on 54 days between 23 July and 23 September. The 6 treatments were conducted with 3 replications at each of 2 soil moisture levels, averaging -0.05 MPa and -0.36 MPa. Water was either added by drip irrigation or withheld to maintain the indicated soil water potentials. Soil moisture stress in CF air reduced yields 9%. Ozone stress alone (NF air), reduced yields 10%. The combined effect of the stresses caused 25% yield loss. The highest O₃ dose, and no moisture stress, reduced yields 55%. There was a significant interaction affecting yields between ozone and moisture stress. That is, soil moisture stress reduced yield losses following exposure to the highest O₃ concentrations but not at low levels of O₃ as in NF air. Root studies involving soil cores taken to 1.4 m depth revealed that moisture stress as measured at the 25 to 45 cm depth increased root growth; however, at highest O₃ concentrations root development decreased especially at soil depths greater than 0.5 m.

Publications: 83/01 to 83/12

- HEGGESTAD, H.E., BENNETT, J.H. and GISH, T.J. 1983. Effects of air pollution and soil moisture stress interactions on soybean yields. *Phytopathology*. 73:966.
- HEGGESTAD, H.E., GISH, T.J., BENNETT, J.H. and DOUGLAS, L.W. Interactive effects of O₃, SO₂ and soil moisture stress on soybeans. Amer. Soc. Agronomy Meeting, Washington, D.C. Abstracts, Agronomic Division. A-5.
- HECK, W.W., ADAMS, R.M., CURE, W.W., HEAGLE, A.S., HEGGESTAD, H.E., KOHUT, R.J., KRESS, L.W., RAWLINGS, J.O. and TAYLOR, O.C. 1983. A reassessment of crop loss from ozone. *Environ. Sci. Tech.* 17:573A-581A.

- BENNETT, J.H., LEE, E.H. and HEGGESTAD, H.E. 1983. Biochemical aspects of plant tolerance to ozone and oxy-radicals: Superoxide dismutase. Chapter 24:413-424. Butterworth Scientific, London.
- MULCHI, C.L., CURTIS, C.R., HEGGESTAD, H.E. and MOORE, L.D. (eds.). 1983. Air Pollution impacts on agriculture and forestry. Northeast Regional Research Publication Project NE 121. Md. Agric. Exp. Sta., College Park, MD.

67.026 CRIS0049397
BIOCHEMICAL MECHANISMS OF TOLERANCE TO AIR POLLUTANT & ENVIRONMENTAL STRESS IN BEAN & TOBACCO PLANTS

LEE E H; ZACHARIUS R; Plant Stress Lab; USDA Agricultural Research Service, Beltsville, MARYLAND 20705.
 Proj. No.: 1209-20172-014-00D

Project Type: INHOUSE
 Agency ID: ARS Period: 15 APR 85 to 15 APR 90

Objectives: To examine (1) the free radical scavengers in plant cells such as ascorbic acid, alpha-tocopherol, & superoxide dismutase that are associated with variation in sensitivity response to atmospheric pollutants, e.g. ozone (O₃) or sulfur-dioxide (SO₂); (2) the use of the chlorophyll-fluorescence method in screening plants (soybean, snapbean & tobacco) for tolerance to O₃ & SO₂. (3) To develop an in vitro system to determine the effects of toxic air pollutants on plant cell and tissue cultures.

Approach: Exposure chambers and controlled environmental chambers for the intact plants and tissue culture studies, which have been especially designed for sated objectives at BARC, will be used to expose vegetation and plant tissues to controlled concentrations of pollutants. Physiological and biochemical studies will include characterization of tolerant and sensitive cultivars with respect to changes in chlorophyll fluorescence, antioxidant compounds, and other biosynthetic pathways that lead to formation or accumulation of toxic products. Studies will involve subcellular fractions of plant tissues and intact plants. Analysis will be made by high-performance liquid chromatography, gel electrophoresis, and spectro-fluorimetry.

67.027* CRIS0074631
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

HART J B; Forestry; Michigan State University, East Lansing, MICHIGAN 48824.
 Proj. No.: MIC101282-H Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 28 DEC 84

Objectives: Establishing an Atmospheric Deposition Network to determine spatial & temporal trends in the supply of beneficial nutrient elements & potentially injurious

substances in precipitation & dry particulate matter deposited in various regions of the United States. Organizing and coordinating research in the SAES, FS, and other research institutions & agencies on the effects of changes in atmospheric deposition on: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters: The health & productivity of domestic food animals, wildlife, and fish; and the corrosion of metals, painted surfaces, masonry, and other materials in machinery or structures.

Approach: Establishment of two monitoring sites in Michigan. Weekly analysis of collected precipitation & dry particulates. Use trends to find effects on forest growth & reproduction.

Progress: 83/01 to 83/09. Research activities were pursued in this project prior to initiation of Project IR-7. Two wet-dry deposition monitoring sites are maintained as part of the National Atmospheric Deposition Program network and National Trends Network: one at Kellogg Biological Station in southwest lower Michigan; and one at the University of Michigan Biological Station in north central lower peninsula Michigan. Precipitation acidity has ranged from extremes of 3.8 to 7.2 with a normal range of 4.2 to 5.7. Simulated acid precipitation of pH 2.5 and below adversely affected greenhouse germination and survival of jack pine. Foliar necrosis and stem lesions were produced on seedlings grown at pH 3.0 and below. Preliminary results indicate episodic simulated acid precipitation of pH 3.0 has no significant effect on survival, growth, or foliar appearance of one-year old jack pine seedlings or competing species of *Carex* sedge. Interpretation of the monitoring network results using information from previous research indicate that neither the extremes or normal acidity ranges are sufficient to preclude the germination and early development of *Pinus banksiana* on typical Udipsamment soils of the region.

Publications: 83/01 to 83/09

MACDONALD, N.W. 1983. The effects of simulated acid precipitation on regeneration and soils in the Jack pine-Grayling sand ecosystem. M.S. Thesis. Michigan State University, E. Lansing, 189p.

67.028* CRIS0012304
PHYSIOLOGICAL ASPECTS OF CROP HARDINESS

LI P H; Horticultural Science and Landscape Architecture; University of Minnesota, St Paul, MINNESOTA 55108.
Proj. No.: MIN-21-074 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 90

Objectives: To elucidate the cold acclimation mechanism in tuber-bearing *Solanum* potatoes & winter spinaches. To investigate the effects of mefluidide protection on post-application growth & development, & on ABA metabolism in chilled maize. To characterize the heat adaptability in the common bean.

Approach: In combination with the use of specific RNA/protein synthesis inhibitor plants growing in a stem-cultured system will be cold acclimated, & proteins from acclimated plants will be extracted & analyzed by SDS-PAGE technique. The effects of mefluidide on corn seed germination under chilling conditions, post-application growth & development, water relations & ABA metabolism will be examined. Experiments planned include the characterization of heat adaptability in common bean germplasm, a comparative study of photosynthesis, & study of the development of reproductive structures between high & low heat adaptable genotypes.

Progress: 83/01 to 83/12. A computerized open-top field exposure chamber system was used to examine the effects of ozone, sulfur dioxide and their mixture on soybean yield. The pollutant exposure regimes simulated the ambient patterns in Minnesota. Numerical analyses showed that log, exponent, sine, arcsine transformations and other related approaches could not satisfactorily explain the relationships between the pollutant exposures and the measured plant parameters. In cooperation with Alberta Government and Scientists, a polynomial - fourier model was successfully developed to explain the pollutant - plant response relationships. For the first time in the literature, this model accounts for the number of pollutant episodes (any concentration above the detection limits); the size (mathematical area under the exposure) of each individual episode and the peak pollutant concentration in each episode. Using this model, soybean pod number, pod weight, seed number, and seed weight were successfully accounted ($r = 0.90$) for the various pollutant treatments.

Publications: 83/01 to 83/12

NOSAL, M. and KRUPA, S.V. 1983. A mathematical model to relate air quality to crop response. J. Air. Pollut. Control Assoc. In Press.
LEGGE, A.H. and KRUPA, S.V. 1983. Air pollutants and their effects on the terrestrial ecosystem. John Wiley and Sons. NY. In Press.

67.029* CRIS0078453
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

KRUPA S V; Plant Pathology; University of Minnesota, St Paul, MINNESOTA 55108.
Proj. No.: MIN-22-080 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetland and soils.

Approach: This objective will be achieved by further developing and maintaining the NC-141/NADP atmospheric chemical deposition network and related local networks. The Program will determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in both wet and dry deposition in various regions of the United States. The Program will also describe the atmospheric processes by which essential nutrients, strong acid and acidifying substances, toxic metals, and other beneficial and injurious substances are transferred from various man-made and natural sources through the atmospheric and are deposited on plant, animals, soils and surface waters. The work of this Network will be developed in parallel with the related Canadian Network for Sampling Precipitation (CANSAP).

Progress: 84/01 to 84/12. Chemical characteristics of aerosol and rain samples collected at five sites in Minnesota during the summer of 1982 were generally similar in regard to the relative proportions of major constituents. On a mass basis, sulfate was the predominant component in the fine particle ($<2.5 \mu m$) fraction. The concentrations of crustal materials in both the aerosol and the rain followed a gradient in which concentrations increased with proximity of the sampling site to the prairie. The concentrations of the crustal materials in the aerosols were correlated with their concentrations in subsequent rain, whereas concentrations of other constituents were not significantly correlated between aerosol and rain. Nitrates and crustal materials were removed more effectively by both wet and dry mechanisms than ammonium, sulfate and other constituents occurring predominantly in the fine fraction. The components in the aerosols were divided by factor analysis into: ammonium sulfates, crustal materials.

Publications: 84/01 to 84/12

GUIANG, S.F., KRUPA, S.V. and PRATT, G.C. 1984. Measurement of S(IV) and organic anions in Minnesota rain. Atmos. Environ. 18:1677-1682.

PRATT, G.C. and KRUPA, S.V. 1985. Aerosol chemistry in Minnesota and Wisconsin and its relation to rain chemistry. Atmos. Environ. (In press).

67.030 CRIS0089853
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIAL

TREVATHAN L E; Plant Pathology & Weed Science; Mississippi State University, Mississippi State, MISSISSIPPI 39762.
Proj. No.: MIS-6707 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the productivity of agricultural crops, forest trees, rangelands,

wetlands, and soils.

Approach: The current situation with regard to atmospheric deposition throughout the state will be evaluated through surveys. Surveys will concentrate on identification of metropolitan areas, sites of heavy industrial development, areas of the state subject to cross-boundary pollution, transport, and other possible sources contributing primarily or secondarily to pollution impact in the state. Literature will be searched for confirmed reports of pollutant impact on plants in Mississippi as well as insults of undetermined etiology which might be attributable to air pollution.

Progress: 84/01 to 84/12. Areas of Mississippi identified as vulnerable to primary or secondary pollution impact are continuing to be evaluated. Previously documented patterns of vegetation injury were confirmed during the growing season. Sensitive species continue to express injury symptoms in proximity to point source emissions. Evidence of ozone damage, during episodes conducive to development of high levels of this photochemical oxidant, was found again particularly in northern Mississippi. Major land resource areas in the state have been identified which are most vulnerable to acid rain effects. A number of sources for funding needed monitoring sites have been investigated.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

67.031* CRIS0069924
EXPLORATORY RESEARCH IN CHEMISTRY

ABBOTT E H; Chemistry; Montana State University, Bozeman, MONTANA 59717.
Proj. No.: MONB00254 Project Type: STATE
Agency ID: SAES Period: 01 JUL 82 to 30 JUN 99

Objectives: To enable chemistry station scientists to handle miscellaneous chemical problems of interest to agriculture which frequently turn up and seem to require prompt attention. Usually these problems will require only a limited amount of work either to provide a solution or to determine whether a full scale investigation is advisable. In the latter case, a research proposal would be prepared and submitted.

Approach: Chemistry faculty who feel that they have identified a problem of immediate importance to agriculture and who wish to seek support under this project will prepare a proposal outlining the problem, its relevance to agriculture, the approach to be taken, and a budget. The proposal will be reviewed by MAES staff and the project leader will determine whether funds should be allocated to the proposed study. Scientists receiving funds from this project will follow the same reporting procedures applicable to other station projects.

Progress: 84/01 to 84/09. One concern of acid deposition is how increased acidity alters the interaction of trace metal complexes with

soil materials. Laboratory studies currently in progress are investigating the interaction of a series of cadmium complexes with hydrous aluminum oxide. The ligands, nitrilotriacetic acid, ethylenediamine-diacetic acid, diethylenetriaminemonoacetic acid and triethylenetetramine are all tetradentate but provide cadmium complexes of varying charge. The interactions of these complexes with the solid material is being monitored with different of pulse polarography. To date the CdNTA system is fairly well characterized. In general hydrous aluminum oxide absorbs sizeable amounts of this complex and the process is hydrogen ion dependent. A second part of this project entails the characterization and synthesis of commercially important organic chemicals of significance to Montana Agriculture. Work completed includes the identification and study of new phytotoxins, insecticides, pheromones, antiviral chemicals, and compounds which speed plant growth. The Cardellina group is exploring the development of new agrochemicals from natural sources - terrestrial plants and marine fauna and flora. Isolation, identification and in house bioassays for plant growth regulatory, antimicrobial and insecticidal activity are the central features of this research program.

Publications: 84/01 to 84/09

ARMOLD, A. and AMEND, J. (1984) The grazing land simulator; compiled for public education. Proceedings of Laramie Conference of Great Plains Agricultural Council.

67.032* CRIS0075343
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

VERMA S B; Agri Engineering; University of Nebraska, Lincoln, NEBRASKA 68583.
Proj. No.: NEB-11-051 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establish and maintain an atmospheric deposition monitoring station as part of anational network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States.

Approach: An automatic sensing wet/dry precipitation collector will be installed at the University of Nebraska Field Laboratory at Mead. This instrument consists of a two-container system with a movable lid designed to expose the "wet" and cover the "dry" container during periods of precipitation, and vice versa during dry periods. Samples of precipitation and dry particulate matter will be collected on a regular weekly schedule, and shipped in specially proveded containers to a central analytical laboratory for analysis. Precautions will be taken to avoid contamination of precipitation samples during collection, transport and storage prior to analysis.

Progress: 83/01 to 83/09. As part of a national network developed in cooperation with the National Atmospheric Deposition Program (NADP), an atmospheric deposition monitoring station was established at the University of Nebraska Field Laboratory at Mead, a rural location in east central Nebraska. Precipitation was collected using an automatic sensing wet/dry precipitation collector and a recording raingauge. Samples were collected every Tuesday on a weekly basis. Samples were then shipped in special containers to the NADP Central Analytical Laboratory in Champaign, Illinois for detailed analysis. Data for the period from January, 1979 to December, 1982 have been analyzed. Average annual precipitation for the four year period was 65 cm (25.6 inches), significantly lower than the long term precipitation normals for the region. Average pH value for the study period was 5.79, indicating nearly neutral conditions. The pH value during individual event weeks varied from 4.2 to 7.6. Lowest pH values tended to occur generally in the fall and winter months. Concentrations of SO(4)-S, NO(3)-N and NH(4)-N in the precipitation ranged from 0 to 6.6 mg , 0.1 to 4.9 mg and 0.01 to 6.3 mg , respectively, for the four-year period. Maxima in concentration of these onstituents occurred primarily in the fall and winter months and minima occurred in the spring and summer months.

Publications: 83/01 to 83/09

NO PUBLICATIONS REPORTED THIS PERIOD.

67.033* CRIS0088967
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

VERMA S B; Agri Meteorology & Climatology; University of Nebraska, Lincoln, NEBRASKA 68583.
Proj. No.: NEB-27-002 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of Nebraska and North Smerica.

Approach: The objective will be achieved by continuing to monitor atmospheric deposition employing an automatic sensing wet/dry precipitation collector installed at the University of Nebraska Field Laboratory at Mead. This collector will be maintained as part of a national network (NADP). Trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation will be characterized.

Progress: 84/01 to 84/12. An atmospheric deposition monitoring station at the University of Nebraska Field Laboratory, Mead was maintained as part of a national network in cooperation with the National Atmospheric Deposition Program (NADP). Analysis of precipitation data for the five year period, 1979-83 is presently in progress. The five year average for SO(4)-S concentration was 0.95 +/-

0.07 mg - . SO(4)-S concentrations ranged from 0.09 to 5.5 mg - . NO(3)-N concentration varied from a minimum of 0.02 mg - to a maximum of 4.9 mg - , with an average of 0.54 +/- 0.04 mg - . NH(4)-N concentration averaged at 0.84 +/- 0.06 mg - . The pH values of precipitation at Mead over the five-year period had a mean of 5.71 +/- 0.06, with a range of 4.16 to 7.64. High pH values were observed generally in the spring and summer months. Low pH values tended to occur primarily in the fall and winter seasons.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

67.034* CRIS0048013
EFFECTS OF ACID PRECIPITATION ON THE RHIZOSPHERE

ALEXANDER M; GRUNES D L; Agronomy; Cornell University, Ithaca, NEW YORK 14853.
Proj. No.: 1931-20780-001-01S
Project Type: COOPERATIVE AGREE.
Agency ID: ARS Period: 01 SEP 82 to 31 AUG 85

Objectives: Determine the effect of simulated acid precipitation on microbial numbers and activities in the rhizosphere, emphasizing nitrogen transformations. To separate the effects of the two main contributors to acid rain, nitrous oxides and sulfur dioxide. Explain unobserved responses to acid rain in order to contribute to the effort to understand and predict the impacts of acid precipitation on the environment.

Approach: Grow alfalfa and wheat on an acid soil of low buffering capacity and exposed to acidified precipitation applied to foliage, soil only and foliage and soil; apply simulated rain to alfalfa on 3 soils varying in buffering capacity and fertility. Data collected for both experiments will include plant yield, dilution plate counts of bacteria and assays of microbial activities in the rhizosphere soil, including denitrification, ammonification, nitrification, and CO₂ evolution.

Progress: 83/01 to 83/12. Mycorrhizae of white pine and red oak were found to be 1984. to acid rain at levels that do not affect plant growth. Experiments simulating chronic exposure indicate that infection is reduced at pH levels Symposium. occurring in the northeastern U.S. At ambient loading rates, infection is affected only in infertile soils. The significance of these results for plant nutrition and stress tolerance, and the possibility of synergistic interactions with other pollutants are currently being studied. Nitrogen mineralization was decreased in 9 of 12 forest soils studied. Soils with low organic matter and low C:N ratios were most affected while N mineralization in soil with high C:N ratios was stimulated. Soil pH had no effect on the response, although liming soil reduced the sensitivity to acid rain. Thus, biological processes may be sensitive to acid rain in soils previously considered resistant because of high pH, although the mechanism by which acid rain affects mineralization is unknown.

Also, this study and studies of N cycling in vegetated soils suggest that N leaching from soils may be enhanced by acid rain.

Publications: 83/01 to 83/12
REICH, P., SCHOETTLE, A., STROO, H., TROIANO, J. and AMUNDSON, R. 1984. Effects of low concentrations of O(2), acid rain and soil type on net photosynthesis and mycorrhizal infection in northern red oak.

67.035 CRIS0095359
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

LASSOIE J P; HUDLER G; PIMENTEL D; Natural Resources; Cornell University, Ithaca, NEW YORK 14853.
Proj. No.: NYC-147460 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality. To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors. To develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: Net photosynthesis and growth studies will be conducted under controlled environmental and field conditions using various tree seedlings common to the eastern United States. All experiments will have a factorial design, using various levels of gaseous pollutants and acid rain. Selected tree factors related to growth and physiology will be examined at 3 study sites with paired plots on soil series considered either sensitive or insensitive to acid rain. Techniques will be developed to study the effects of acid rain on certain pathogenic bacteria. The direct and indirect environmental impacts of pesticide air pollutants upon plant production will be studied.

67.036* CRIS0096268
EFFECTS OF ATMOSPHERIC DEPOSITION ON CANOPY AND SOIL PROCESSES

MITCHELL M J; WHITE E H; RAYNAL D J; School of Biology Chem & Ecolo; State University of New York, Syracuse, NEW YORK 13210.
Proj. No.: NYZ-2533-01-002 Project Type: STATE
Agency ID: OCI Period: 28 MAY 85 to 27 MAY 89

Objectives: To project short and long-term effects of atmospheric deposition on nutrient status of a northern hardwood forest ecosystem. To determine whether atmospheric deposition could be causing nutritionally mediated changes in forest productivity. To characterize key processes regulating atmospheric deposition on forest element cycling.

Approach: (Task A) Establish a site at the Huntington Forest in the Adirondack Mountains for intensive sampling of soil chemistry and nutrient cycling. Event sampling of solutions which consist of the preceeding dry period and the following wetfall will be taken during the growing season. (Task B) A comprehensive chemical analysis of the vegetation, forest floor, mineral soils and soil solutions will be completed to provide estimates of elemental fluxes in litter and the soil system.

67.037 CRIS0091216
INVESTIGATION OF THE EFFECTS OF ACID RAIN ON
FOOD CROPS AND SOILS

REDDY M; Plant Science; Agric & Tech
 University of N C, Greensboro, **NORTH CAROLINA**
 27412.

Proj. No.: NC.X-065-5-84-130-1

Project Type: 1890/T

Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 86

Objectives: To determine the sensitivity of soybean, tobacco, lettuce and green beans to different levels of acid rain; to measure the variation in the sensitivity of the crop varieties to acid rain; to appraise the effect of acid rain on soil properties and fertility; to determine the specific effects of acid rain on the crops in terms of particular plant tissue attacked, and resulting symptoms and abnormalities.

Approach: Soybean, tobacco, lettuce and green beans will be treated with acid rain in the field to determine their sensitivity. Four different pH levels of acid rain and four applications will be studied. Two different soils will be used for the study. The experimental design will be split plot with four replications. Any abnormalities and symptoms of the crops will be identified and evaluated. The leachings from plants after treatment with acid rain will be collected and analyzed for nutrient status. The crop yields will be measured and quality evaluated. Soil samples from each treatment will be analyzed and fertility parameters measured and appraised. Statistical significance of the treatment effects will be determined and application of the results evaluated.

Progress: 84/01 to 84/12. The objectives of the investigation are (1) to determine the sensitivity of different varieties of soybean and green bean to various levels of acid rain, (2) to identify the specific effects of acid rain on the crops in terms of particular plant tissue attacked, and resulting symptoms and abnormalities, and (3) to appraise the effect of acid rain on soil properties and fertility. The treatments include acid rain of five different pH values (2.5, 3.2, 4.0, 4.8, and pH 5.6 as control) with twice a week application. The soil selected for the study is Enon sandy loam from the Piedmont region. The experimental design is split-split-plot with four replications. The experiment was conducted using simulated acid rain. A rain simulation

system was developed using electric pumps, pipes, and proper size nozzles. The simulation of acid rain is made as much as possible to reflect natural rainfall. The acidity of the simulated rainfall is adjusted with sulfuric and nitric acids to pH levels specified above. The selected pH levels of simulated acid rain are representative of the natural acid rainfall occurring in the southeastern U.S. from time to time. The crops are grown in plastic pots under greenhouse conditions, adopting normal agronomic practices. The crops are subjected to simulated acid rainfall of various pH levels twice a week. The experiments are in progress and results will be included in the next report.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

67.038* CRIS0089959
ACID PRECIPITATION RESEARCH

BATEMAN D F; Agricultural Research Service; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.

Proj. No.: NC09044 Project Type: SPECIAL GRANT
 Agency ID: CSRS Period: 15 APR 83 to 31 JUL 84

Objectives: Determine the nature and magnitude of effects of atmospheric acid deposition on terrestrial ecosystems with primary emphasis on major agricultural crops of the United States.

Approach: Proposals will be solicited from the agricultural research community to study the impact of acidic and acidifying substances, from the atmosphere, on major agricultural crops. Greenhouse, field and laboratory investigations will be employed. Measurements will be made of plant response to variable doses of acidity including changes in physiological activity and in quality and quantity of biomass and crop yield. Ambient amounts of pollutant/nutrient deposition, both wet and dry, will be the primary focus for experimentation. Effects will be quantified relative to common agricultural practices.

Progress: 84/01 to 84/12. Ten projects are underway with the overall objective of improving understanding of the beneficial and/or detrimental effects of acidic and acidifying substances from the atmosphere on agricultural crops. Six institutions have received subcontracts: NCSU, University of Illinois, University of California-Riverside, University of Tennessee, VPI&SU, and Ohio University. Specific research activities include the epidemiology of major crops when impacted by acid deposition, interaction between ozone and acid deposition, impact of acid fog on major California crops, and extensive screening of agricultural species for sensitivity to acidic deposition. The specific projects funded all fall within the research priorities identified by the National Atmospheric Deposition (IR-7) - Technical Committee.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

67.039* CRIS0087076
THE ASSESSMENT OF AIR QUALITY EFFECTS ON CROP PRODUCTION

HECK W W; BLUM U; Botany; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
Proj. No.: NC05520 Project Type: STATE
Agency ID: SAES Period: 01 JAN 82 to 30 SEP 86

Objectives: Assess the effects of O₃ and SO₂ on crop production and how these gases affect the crops; determine the primary site of action; and initiate the development of predictive capabilities. Develop some fundamental understanding of the effects of acidic precipitation and carbon dioxide on crop production.

Approach: Experiments will utilize the Continuous Stirred Tank Reactor (CSTR) chambers in greenhouse and Phytotron studies and the open-top chambers for field work. All chamber systems utilize continuous gas analyzers on a shared-time basis for monitoring pollutant concentrations. The CSTR chambers are designed for gas exchange studies and routine monitoring of CO₂, water vapor and test gases can be made at the chamber inlet or outlet. Plant response determined will be dictated by the objectives of the experiment. Exposures will be episodic or chronic over the life of the plant. Rate functions will be generated in many studies.

Progress: 84/01 to 84/12. Pool concentrations of glycine, serine and pyruvic in white clover (*Trifolium repens* L. cv.) 'Tillman' grown under 550 micro E m-2s-1 (PAR) were significantly reduced within 24 hr after transfer of plants to 285 micro E m-2s-1. These reduced concentrations stabilized in the 2nd trifoliate within three days. Data suggest that when plants are transferred from one environment to another they should have from one to three days to acclimate before metabolic studies are undertaken. Plants so acclimated for 91 hr and then exposed to ozone (0.15 ppm, 4 hrs) showed an initial reduction in glycine and serine in the 2nd trifoliate leaves. The concentration of each metabolite then increased with increasing exposure time to 4 hrs. There was no effect on ozone on 6-phosphogluconic acid. Phaseous vulgaris lines were screened for relative susceptibility to O₃ (1186 lines) and SO₂ (58 lines). Seed increases were done on a sampling of these lines for more in-depth studies. The field studies utilized 3 resistant and 3 sensitive bean lines (3 ozone concentrations, 4 SO₂ concentrations, and 2 reps) in a split plot design. The relative resistance/sensitivity separations reported in the Phytotron screen were substantiated in the field study. Computerization of the bean data base was completed.

Publications: 84/01 to 84/12
BLUM, U., MROZEK, E. JR., and JOHNSON, E.
Investigation of ozone (O₃) effects of 14C distribution in Ladion clover.

Environmental and Experimental Botany. 23(4):369-378.
BLUM, U., HEAGLE, A.S., and LINTHURST, R.A. 1983. The effects of ozone on fescue-clover forage production: regrowth, yield, and quality. Environmental and Experimental Botany. 23(2):121-132.
HECK, W.W., BLUM, U., REINERT, R.A., and HEAGLE, A.S. 1983. Effects of air pollution on crop production. In "Strategies of Plant Reproduction." pp. 333-350. Allanheld, Osmun & Company Publishers, Inc., Totowa, NJ.
MONTES, R.A., BLUM, U., HEAGLE, A.S., and VOLK, R.V. 1983. The effects of ozone and nitrogen fertilizer on tall fescue, ladino clover and fescue-clover mixture. II. Nitrogen content and nitrogen fixation.
HECK, W.W., BLUM, U., BOSS, W.F., HEAGLE, A.S., LINTHURST, R.A., REINERT, R.A., REYNOLDS, J.F., and ROGERS, H.H. Perspectives of air pollution research on plants. In Reviews of Environmental Toxicology I. E. Hodgson, ed., pp. 173-249.

67.040* CRIS0089835
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

BRUCK R I; COWLING E B; Plant Pathology; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
Proj. No.: NC01607 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: 1) To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. 2) To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands and soils; b) the health and productivity of domestic animals, wildlife, and fish; c) the chemical composition of surface and groundwaters; and d) atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: A. Samples of precipitation and dry particulate matter will be collected weekly at five states in NC and analyzed for SO₄, NO₃, PO₄, Cl, NH₄, K, Na, Ca, Mg, pH, total and free acidity, and electrical conductivity. B. Measurements will be made of the input of nutrients from the atmosphere to various crops and toxic effects of precipitation constituents on crop plants and forest trees.

Progress: 84/01 to 84/12. A network of 7 NADP monitoring stations strategically placed in the Coastal Plain, Piedmont and Mountains of N.C. continued weekly monitoring to measure the chemistry of wet and dry atmospheric deposition. Plans were initiated to install an 8th station on the summit of Mt. Mitchell, N.C. to assess deposition on the highest point in the eastern U.S. Research programs investigating the effects of simulated

acidified precipitation on 5 agronomic crop plantpathosystems continued. Preliminary results indicate that the rate of epidemic progression of Potato Late Blight and Peanut Leaf Spot can be reduced by application of simulated rain below pH 4.0; while increases in the rate of disease were observed in Soybean Brown Spot and Alfalfa Leaf Spot. Studies correlating the incidence and forms of anthropogenic pollution on high altitude boreal montane forest decline were initiated. It was observed that declining trees were more abundant at high west facing aspects where higher loading of soil and tissue lead, cadmium, copper, and zinc were observed. The incidence and vigor of red spruce and Fraser fir ectomycorrhizae was also reduced in affected areas. Although these preliminary data are only correlative, it appears that atmospheric deposition may play a significant role in stressing these ecosystems.

Publications: 84/01 to 84/12

- BRUCK, R.I. 1984. Boreal montane forest decline. Perspectives of a Forest Pathologist. Annual Meeting of TAPPI. TAPPI Journal 37:159-163.
- BRUCK, R.I., ROBARGE, W.P., REYNOLDS, K.M., REBERTUS, R., PYE, J., and HALEY, K. 1984. Observations of boreal montane decline in the southern Appalachian Mountains--Soil and vegetation studies. U.S. EPA, NAPAP Peer Review Document.
- MEIER, S., SHAFER, S., BRUCK, R.I., and GRAND, L.F. 1984. Effects of simulated acid rain on ectomycorrhizae of loblolly pine. Proc. Southwide Forest Disease Workshop 10:40.
- BRUCK, R.I., and MEIER, S. 1984. Boreal montane forest decline and dieback: Why and Who's Next. Proc. Southwide Forest Disease Workshop 10:37.

67.041 CRIS0083066
RESPONSE OF FIELD CROPS TO SELECTED AIR POLLUTANTS

HEAGLE A S; Plant Pathology; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
Proj. No.: NC05486 Project Type: STATE
Agency ID: SAES Period: 01 OCT 80 to 30 SEP 85

Objectives: Perform field experiments to determine plant growth and yield response to different doses of O(3), SO(2) and NO(2), and simulated acid rain. Identify factors that alter plant response to pollutants to improve protocols for dose-response research. Determine interactions between plant parasites and pollutants. Develop protocols for screening crop cultivars for resistance to pollutants.

Approach: Expose plants to gaseous pollutants in open-top field chambers. doses of single or mixed gases will simulate and bracket in magnitude those that occur in ambient air. expose plants to simulated acid rain at four pH levels using ratios of sulfuric and nitric acid that usually occur in ambient acid rain. Factors that affect plant response and interactions between pollutants and parasites will be included in dose-response designs.

Progress: 84/01 to 84/12. Field grown flue-cured tobacco 'McNair 944' was exposed throughout growth to chronic doses of ozone in 22 open-top chambers to determine relationships between the ozone dose and marketable leaf yield. The ozone doses were applied by adding ozone to the variable amounts of ozone present in ambient air. Ozone was added for 7 or 12 hr per day in different constant amounts or in different proportions to the ambient ozone concentration to determine whether exposure dynamics affected the yield response. For each of the ozone addition protocols, marketable leaf weights were less with increased ozone. The response was similar for 7 hr constant and 7 hr proportional treatments. The 12 hr proportional treatments caused more tobacco yield decrease than did the 7 hr proportional treatments. Field-grown soybean 'Davis' was exposed throughout growth to chronic doses of ozone in 24 open-top chambers to determine whether soil moisture levels affect the ozone dose-yield response relationships. For plants with adequate soil moisture, a significant ozone dose-yield loss relationship was described. For plants with severe moisture stress, the ozone effect was not significant.

Publications: 84/01 to 84/12

- HECK, W.W., CURE, W.W., RAWLINGS, J.O., ZARAGOZA, L.J., HEAGLE, A.S., HEEGESTAD, H.E., KOHUT, R.J., KRESS, L.W., and TEMPLE, P.J. 1984. Assessing Impacts of Ozone on Agricultural Crops: I. Overview. J. Air Pollution Control Assoc.
- HECK, W.W., CURE, W.W., RAWLINGS, J.O., ZARAGOZA, L.J., HEAGLE, A.S., HEEGESTAD, H.E., KOHUT, R.J., KRESS, L.W., and TEMPLE, P.J. 1984. Assessing Impacts of Ozone on Agricultural Crops: II. Crop yield functions and alternate exposure.
- UNSWORTH, M.H., HEAGLE, A.S., and HECK, W.W. 1984. Gas exchange in open-top field chambers: I. Measurement and analysis of atmospheric resistance to gas exchange. Atmospheric Environment 18:373-380.

67.042 CRIS0097058
RESPONSE OF FIELD CROPS TO SELECTED AIR POLLUTANTS

HEAGLE A S; Plant Pathology; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
Proj. No.: NC05613 Project Type: STATE
Agency ID: SAES Period: 01 OCT 85 to 30 SEP 90

Objectives: Determine plant growth and yield response to different doses of O(3), SO(2), and NO(2), and simulated acid rain. Identify factors that alter plant response to pollutants to improve protocols for dose-response research. Determine interactions between plant parasites and pollutants. Develop protocols for screening crop cultivars for resistance to pollutants.

Approach: Expose plants to gaseous pollutants in open-top field chambers. Doses of single or mixed gases will simulate and bracket in magnitude those that occur in ambient air. Expose plants to simulated acid rain at different pH levels using ratios of sulfuric

and nitric acid that usually occur in ambient rain. Factors that affect plant response and interactions between pollutants and parasites will be included in dose-response designs.

67.043 CRIS0088812
INTERACTION OF AIR POLLUTANTS AND PATHOGENS ON CROP PLANTS

REINERT R A; Plant Pathology; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: NC05530 Project Type: STATE
 Agency ID: SAES Period: 01 OCT 82 to 30 SEP 87

Objectives: Determine the effects of NO(2), SO(2), and O(3) alone and in combination on plant growth, yield nutrient allocation, acid rain, and plant pathogen-host relationships. Determine how the air and soil environment modify these interactions and develop screening procedures to determine if resistance to NO(2), SO(2), and O(3) can be maintained at ambient dose levels.

Approach: Exposures to the three pollutants will be carried out in greenhouse exposure chambers and open-top field chambers in charcoal-filtered air. Acid rain simulation facilities in charcoal filtered air will be developed. Plant species chosen will be horticultural crop species. Plants will be exposed once or repeatedly over the growth cycle and plant response to the pollutants will be evaluated at various stages during the life cycle. Measures of foliar injury, plant weight, flower size and number, fruit size and yield as well as other measurements will be determined. Changes in host-parasite pollutant interactions on the plant will be determined similarly.

Progress: 84/01 to 84/12. The following systems were constructed and tested to update methodology concerning the present CRIS-Project: 1) a charcoal filtered air (CF) system for three greenhouse sections, 2) twenty plant exposure chambers 4ft dia. by 4 1/2 ft tall placed in a 30x40 ft CF greenhouse section and facilitated with a pollutant dispensing and monitoring system, and 3) twelve rotating tables for exposing plants to simulated rain at different pH levels placed in a 20x40 ft CF greenhouse section. Various plant species including tobacco, snap bean, soybean, peanuts, watermelon, cantaloupe, beets, tomatoes, radish, pepper, marigold, impatiens and nasturtium were grown in both CF or non-filtered greenhouse air. All species in the NF air developed ozone injury but did not develop injury in the CF air. *Glyceria nubigena* and *Calceola rugelia*, rare and endangered plant species in the Greater Smokies National Park, are currently being grown in large numbers to study their soil, nutritional, photoperiod and temperature requirements, and their sensitivity and growth following exposure to ozone and sulphur dioxide.

Publications: 84/01 to 84/12

FRANEL, D.R., BENSON, D.M., and REINERT, R.A. 1984. Response of shore juniper to ozone alone and in mixture with sulfur dioxide and nitrogen dioxide. *HortScience* 19:694-695.

KLARER, C.I., REINERT, R.A., and HUANG, J.S. 1984. Effects of sulfur dioxide and nitrogen dioxide on vegetative growth of soybeans. *Phytopathology* 74:1104-1106.

REINERT, R.A. 1984. Plant response to air pollutant mixtures. *Ann. Rev. of Phytopathology* 22:421-442.

REINERT, R.A., DUNNING, J.A., HECK, W.W., BENEPAL, P.S., and RANGAPPA, M. 1984. Screening of bean (*Phaseolus vulgaris*) for sensitivity of Ozone. *HortScience* 19:86-88.

67.044* CRIS0094165
ACIDIC DEPOSITION AND ITS INFLUENCE ON MOBILIZATION OF ALUMINUM IN ACID SOILS

ROBARGE W P; Soil Science; N Carolina State University, Raleigh, **NORTH CAROLINA** 27650.
 Proj. No.: NC03898 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 84 to 30 SEP 89

Objectives: Develop and use analytical techniques to assess effects of acidic deposition on soil ecosystems with emphasis on: rate of Al release as a function of acidic input; sources of Al that react rapidly with acidic inputs; and suitability of radioisotopes as tracers for Al reactions in soils.

Approach: Pressure membrane filters will be used to measure rate of Al release as a function of acidic input. Labile and total Al in leachates will be determined with 8-hydroxyquinoline reagent. Ion activities will be calculated using computerized chemical models. A combination of soil titrations at constant pH and extracting solutions will be used to quantify sources of Al that react rapidly with acidic input. Batch equilibrations and leaching studies with radioisotopes of Sc, La and Ga will be used to test their suitability as tracers for Al reactions in soils.

67.045 CRIS0140847
EFFECTS OF ATMOSPHERIC CHEMICALS ON PLANT GROWTH, DEVELOPMENT, YIELD AND QUALITY

HECK W W; HEAGLE A S; MILLER J E; Air Qual/plant Grow & Develop Research Unit; USDA Agricultural Research Service, Raleigh, **NORTH CAROLINA** 27607.

Proj. No.: 6645-20790-016-00D
 Project Type: INHOUSE
 Agency ID: ARS Period: 01 OCT 86 to 01 SEP 91

Objectives: Determine and understand the effect of atmospheric chemicals (i.e., O₃, SO₂, NO₂, CO₂, SO₄, NO₃-) and their mixtures on growth, development, yield, and quality of selected plant species and cultivars; determine how abiotic and biotic stresses affect plant response to atmospheric chemicals; examine

effects of air quality on selected components of rhizosphere microbial communities.

Approach: Research will be performed in controlled environments, greenhouses & field plots. Exposure chambers will be used to maintain a known chemical climate around the test plants. Physiological, microbial, pathological & biochemical methodologies will be used to study the effects of atmospheric chemicals on these plants. Controlled environment research permits close control of temperature, light & humidity; CSTR chambers allow for automatic water and control of CO₂. Inlet & exhaust monitoring is done to study whole plant photosynthesis, respiration, transpiration & pollutant gas uptake. Greenhouse facilities utilize charcoal filtration, wetpad cooling (summers) & air duct heating (winter) for growing & exposing test plants to atmospheric chemicals. CSTR chambers (for gaseous chemicals) & a rain system with turntables (for simulated rain) permit flexibility in the study of plant response. Field studies utilize open-top chambers with plants grown in the field or inputs (for selected studies). Pollutant monitoring & dispensing are accomplished in air-conditioned trailers within the field area.

67.046* CRIS0042179
EFFECTS, FATES AND TRANSFORMATIONS OF
ATMOSPHERIC CHEMICALS ON PLANT GROWTH AND
DEVELOPMENT

HECK W W; HEAGLE A S; REINERT R A; Field Crops Post-harvest Res Biomaterials Conversion Lab; USDA Agricultural Research Service, Raleigh, NORTH CAROLINA 27607.
 Proj. No.: 6645-20790-002-00D

Project Type: INHOUSE
 Agency ID: ARS Period: 17 JAN 75 to 30 SEP 85

Objectives: Investigate: biochemical, physiological & growth responses of plants to atmospheric chemicals; dose-response relationships as the primary experimental protocol; plant response as affected by environmental & biotic factors; continued improvement of exposure methodology; plants as sinks for atmospheric chemicals.

Approach: Use the continuous stirred tank reactor CSTR exposure system for greenhouse & phytotron control of atmospheric chemicals. Open-top chambers will be used for field studies with automated dispensing & monitoring systems & computer controlled data acquisition. Special rain dispensing (greenhouse & field) & rain exclusion (field) systems will be developed, tested, & used for acid rain studies (as part of the acidic precipitation research). Initially we will use both acute & acute-chronic dose-response exposure regimes. Plant responses include: chemical uptake or release, net photosynthesis, transpiration rate, stomatal response, growth & yield parameters, nutrient ratios, changes in metabolic pools, plant injury. Meteorological studies will be integrated with field studies to help

interpret & predict plant response on a national basis. Response measures may be measured over time to develop rate functions.

Progress: 82/01 to 82/12. Yield of unginned cotton at seasonal 7 hr./da. O₃ conc of about 0.03, 0.05, 0.07, 0.09 and 0.11 ppm. O₃ was 3650, 3180, 2780, 2200 and 1600 kg./ha., respectively. Sulfur dioxide at seasonal 4 hr./da. SO₂ conc of 0.00, 0.03, 0.12 and 0.36 ppm. did not decrease cotton growth or yield and did not measurably change cotton response to O₃. An increase in soybean yield and growth was found with increasing CO₂ in season-long studies with elevated CO₂ for 24 hr./da. The first 200 ppm. of CO₂ over ambient caused the greatest effect. Increases in germination and seed development were not affected by CO₂. Uptake of O₃ was shown to be controlled mainly by stomatal resistance (r(s)) which was similar for plants grown in the field and in open-top chambers. Low concentrations of NO₂, SO₂, and O₃ in various mixtures caused reduced yields of soybean and snap bean when compared with control plants in charcoal-filtered open-top chambers. Snap bean lines selected as resistant or sensitive to O₃ in an acute phytotron screen (using visible injury) maintained their relative resistance/sensitivity for yield response in a chronic field exposure to O₃ (using open-top chambers). Approximately 50 additional O₃ resistant snap bean lines have been identified from a screen of 1150 lines. An acid rain exclusion system was designed and tested with soybean. Effects of increasing rain acidity were not found in these preliminary tests.

Publications: 82/01 to 82/12

- HEAGLE, A.S. and LETCHWORTH, M.B. 1982. Relationships between injury, growth and yield effects of ozone on four soybean cultivars at different light intensities. J. Environ. Quality 11:690-694.
 HECK, W.W. 1982. Future directions in air pollution research. In: Effects of Gaseous Air Pollution in Agriculture and Horticulture. (Unsworth, M.H. and Ormrod, D.P. Eds.) pp. 411-435. Butterworth Scientific, London.
 HECK, W.W., TAYLOR, D.C., ADAMS, R., BINGHAM, G., MILLER, J., PRESTON, E., and WEINSTEIN, L. 1982. Assessment of crop loss from ozone. J. Air. Pollu. Contr. Assoc. 32:353-361.
 JOHNSTON, J.W. and HEAGLE, A.S. 1982. Response of chronically ozonated soybean plants to an acute ozone exposure.

67.047* CRIS0074748
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON
AGRICULTURE, FORESTRY, SURFACE, WATERS, AND
MATERIALS

WEIDENSAUL T C; Environmental Studies Lab; Ohio Agric Res and Devlp Center, Wooster, OHIO 44691.
 Proj. No.: OH000627 Project Type: HATCH
 Agency ID: CSRS Period: 02 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America and assess the effects of atmospheric deposition on the following: productivity of agricultural crops, forest trees, rangelands, wetlands, and soils and on the chemical composition of surface and ground waters.

Approach: Wet and dry atmospheric deposition samples are collected at weekly and bi-monthly intervals, respectively and will be analyzed for various components. Spatial and temporal trends in deposition will be determined via data analyses of stored information from around the U.S. Studies will be conducted to determine the influence of natural soil solution and atmospheric acidification as well as field and laboratory studies to assess the impacts of atmospheric acidity on forest productivity and soil microorganism activity. Leachability of soils from Ohio, PA., NY, and Ontario will be studied re exposure to acid gases and simulated acidic deposition.

Progress: 84/01 to 84/12. Wet and dry deposition continue to be monitored at Caldwell and Wooster, Ohio. The total wet deposition of monitored materials at the two locations between Jan 1 and Dec 31, 1983 is recorded below. pH values are not normalized for total rainfall re hydrogen ion deposition.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

67.048 CRIS0089836
CHEMISTRY OF ATMOSPHERIC DEPOSITION-EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIAL

WINGTON P J; Forestry; Oklahoma State University, Stillwater, OKLAHOMA 74078.
Proj. No.: OKLO1856 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America.

Approach: Samples of precipitation and dry deposition will be collected at Clayton, Oklahoma, and possibly at a second site at Woodward, Oklahoma. Samples will be collected and processed according to prescribed procedures and sent to the Illinois State Water Survey laboratory for analysis. Data will be submitted for inclusion in the IR-7 National Atmospheric Deposition Program.

Progress: 84/01 to 84/12. Operation of the only National Atmospheric Deposition Program (acid rain) monitoring station in eastern Oklahoma was continued during 1984. The station is located at a forest hydrology research area, near Clayton, Oklahoma. This project has provided valuable information for the forest hydrology research program as well as information concerning acid rain. The average pH of precipitation for the year was

approximately 4.7. Based on the findings of this project, outside funds were obtained through the Oklahoma State University Center for Water Research to expand acid rain monitoring in Southeast Oklahoma. Currently, no graduate students are involved with this project.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

67.049* CRIS0047991
COMBINED CYCLE BIOMASS ENERGY RESEARCH

THRESHER R W; REISTAD G M; RESCH H; Energy Research & Dev Inst; Oregon State University, Corvallis, OREGON 97331.
Proj. No.: 7006-20195-001-G Project Type: GRANT
Agency ID: ARS Period: 29 SEP 82 to 31 MAR 85

Objectives: Determine the optimum method of burning biomass materials in a thermodynamically efficient and environmentally sound manner to produce electricity. The feasibility of a 10 megawatt directly fired combined cycle power plant utilizing forest slash and agricultural residues will be determined.

Approach: The baseline plant will be analyzed to determine thermal efficiency, mechanical reliability, resource availability, air emissions, engineering constructability, financial and economic viability, and safety requirements. Various design trade-offs will be considered and analyzed to evaluate the potential of changes to the baseline concept. These alternate concepts will be analyzed in order to determine the plant design with the greatest overall viability, considering the available fuel sources, commercially available components, and the real world market for electrical energy.

67.050 CRIS0093462
STRESS INDICATORS OF DIFFERENTIAL PLANT RESPONSE TO ACIDIC PRECIPITATION AND OZONE

PELL E J; Center For Air Envir Studies; Pennsylvania State University, University Park, PENNSYLVANIA 16802.
Proj. No.: PEN-2-2394

Project Type: SPECIAL GRANT
Agency ID: CSRS Period: 01 JUL 84 to 30 JUN 86

Objectives: Characterize the interaction between acidic precipitation and O(3) based on ethylene emission and RuBPCase activity. Develop a protocol for screening large numbers of species for ethylene response to acidic precipitation with or without O(3). Compare impact on field grown crops of acidic precipitation on a tolerant and sensitive species based on laboratory predictions.

Approach: Greenhouse grown plants will be exposed to O(3) or charcoal filtered air followed by simulated acidic rain treatments at

PH 2.8, 3.8, 4.6, or 5.6. Following the rain treatments ethylene emission or ribulose-1,5-bisphosphate carboxylase activity will be measured on representative foliage. Selected species will be grown in the field and treated with simulated rain 3 times per week at the pH levels itemized above. Ambient rain will be excluded and additional soil moisture provided with drip irrigation. At harvest yield will be determined.

67.051 CRIS0071527
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY IN THE NORTHEAST

PELL E J; Plant Pathology; Pennsylvania State University, University Park, **PENNSYLVANIA** 16802.

Proj. No.: PEN02313 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 77 to 31 DEC 83

Objectives: Determine physiological, biochemical and morphological mechanisms of susceptibility and resistance of plant cultivars to air pollutants and determine whether these are affected by interactions with biotic factors in the environment; identify the genetic mechanism of resistance of plant cultivars to air pollutants.

Approach: Histological (electron and light microscopy) and histochemical techniques will be used to identify biochemical and morphological differences between resistant and susceptible lines. Ability of cultivars to produce "antioxidant type enzymes" in response to ozone stress will be compared. Attempt to identify the heritability of ozone resistance or susceptibility in potatoes by screening for ozone response in parents, backcrosses, F(1) and F(2) generations of susceptible and resistant strains.

Progress: 77/01 to 83/12. The heritability of ozone tolerance in potato was investigated. Two 7 x 7 diallels were constructed and foliar ozone response of parents and progeny were examined in the field and laboratory. Statistical analysis revealed that heritability was largely additive but that a component was also attributed to specific combining ability. The dominance factor fits best into models for tolerance. F(2) and back crosses from germplasm used in the initial genetics study have been completed. The advanced generations will be included in additional studies to improve the utility and reliability of the model to explain heritability of ozone tolerance. The physiological mode of ozone response was studied in two potato cultivars, 'Norchip' and 'Cherokee', tolerant and sensitive, respectively. Neither differential gas exclusion nor response of cell types explained the contrasting cell behavior. Leaf protoplasts from both cultivars were exposed to ozone "in vitro". Two cell responses were observed viz. lysis and decreased staining with fluorescein diacetate, a vital stain. The responses appeared to be independent and non-sequential. Protoplasts from both cultivars behaved

similarly. Experiments were conducted to examine the effects of ozone and nitrogen dioxide on yield and quality of potatoes and alfalfa. Ozone and nitrogen dioxide can reduce weight, number, and total solids content of potato tubers. Ozone can initiate increases in reducing sugars and glycoalkaloids of potato tubers.

Publications: 77/01 to 83/12

DEVOS, N.E., PELL, E.J., HILL, R.R., Jr., COLE, R.H. 1983. Laboratory versus field response of potato genotypes to oxidant stress. *Plant Disease* 67:173-176.

LOTSTEIN, R.J., DAVIS, D.D., PELL, E.J. 1983. Quality of tomatoes harvested from plants receiving chronic exposures to sulfur dioxide. *HortScience* 18:72-74.

PELL, E.J. PEARSON, N.S. 1983. Ozone induced reduction in quantity of 1,5-ribulose biphosphate carboxylase in alfalfa foliage. *Plant Physiology* 73:185-187.

PELL, E.J., PEARSON, N.S. Ozone induced reduction in quantity and quality of two potato cultivars. *Environ. Pollut.* (accepted for publication).

67.052 CRIS0091510
REDUCING THE INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

PELL E J; Plant Pathology; Pennsylvania State University, University Park, **PENNSYLVANIA** 16802.

Proj. No.: PEN02717 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To characterize effects of air pollutants on plant growth, development, reproduction, yield and quality; to determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with biotic and abiotic factors; to develop methods and materials to ameliorate the effects of air pollutants on plants.

Approach: Potato plants will be exposed to increasing doses of ozone and sulfur dioxide in open top chambers and effects on yield, starch, glycoalkaloid sugars and dry matter determined. Tubers of various crosses will be collected and plants grown in the greenhouses exposed to ozone and rated for injury. Data will be subjected to analysis and modeling to determine nature of heritability.

Progress: 84/01 to 84/12. A study was conducted to determine the inheritance of ozone tolerance in potato. A model for inheritance of traits in autotetraploids, in general, was developed to quantify the importance of additive, digenic, trigenic and quadrigenic effects on a single locus. The model was applied to the inheritance of the ozone response in two pairs of sensitive and tolerant cv. of potato, respectively, viz. 'Cherokee' and 'Norchip' and 'Cherokee' and 'Chieftain'. The progeny tested have been described in previous reports. The progeny were exposed to 0.55 ppm ozone for 3 hr in order to insure a spectrum of foliar responses. The data was then subject to a generation mean analysis. Genes

for additivity accounted for 70 and 90% of the inheritance in the two cases, respectively. Digenic and quadrigenic effects accounted for significant although relatively minor effects. Differences in inheritance estimates for the two pairs studied may reflect the smaller population base achieved for the second pair. Inbreeding depression accounted for 3.5% of the inheritance. Based on results of this study we conclude that selection is a better means of crop improvement than hybridization. Caution must be taken in extrapolating these results to nontested cultivars. The effects of acid rain on ethylene emission were measured in radish, soybean and potato. At pH 2.8 ethylene was emitted in all 3 species. At higher pH's the response was not detected.

Publications: 84/01 to 84/12

- PELL, E. J., PEARSON, N. S. 1984. Ozone induced reduction in quantity and quality of two potato cultivars. *Environ. Pollut.* 35:345-352.
- SINN, J. A. P., PELL, E. J., KABEL, R. Uptake of nitroten dioxide by potato plants. *J. Air Pollut. Control Assoc.* 34:668-669.
- SINN, J. A. P., PELL, E. J. 1984. Impact of nitrogen dioxide on yield and quality of greenhouse grown potato plants. *J. Soc. Amer. Hort. Sci.* 109:481-484.
- ARNY, C. J. 1984. Effects of simulated acid rain treatments on ethylene production by potato, radish and soybean leaf tissue. M.S. Thesis, The Pennsylvania State University.

67.053* CRIS0079170
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

JONES U S; Agronomy & Soils; Clemson University, Clemson, SOUTH CAROLINA 29631.
 Proj. No.: SC00382 Project Type: HATCH
 Agency ID: CSRS Period: 01 MAY 79 to 30 SEP 82

Objectives: Determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the U. S. Determine the effects of atmospheric deposition on plants and soils.

Approach: Samples of precipitation and dry particulate matter will be collected weekly at Clemson, SC and analyzed for SO(4), NO(3), PO(4), Cl, NH(4), K, Na, Ca, Mg, pH, total and free acidity, and electrical conductivity. Measurements will be made of the input of nutrients from the atmosphere to various crops and toxic effects of precipitation constituents on plants and soils.

Progress: 82/10 to 82/12. Particulates and precipitation continue to be collected weekly at Clemson using an Aerochem metric wet/dry precipitation collector. Chemical analyses of the atmospheric deposition is continuing. Variations in total annual atmospheric S and N deposition are well correlated with total annual precipitation in the Southeastern United States.

Publications: 82/10 to 82/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

67.054 CRIS0092360
REDUCING INFLUENCE OF AIR POLLUTION ON PLANT PRODUCTIVITY

FONG F; Soil & Crop Sciences; Texas A&M University, College Station, TEXAS 77843.
 Proj. No.: TEX03216 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 83 to 30 SEP 88

Objectives: To determine mechanisms of tolerance of plant cultivars to air pollutants and interactions with abiotic factor.

Approach: Dinitroaniline herbicides and other pesticides have been reported by this laboratory (Amthor J., F. Fong. 1980) and other groups to alter the ozone sensitivity of higher plants. The biochemical and physiological basis for these "iatrogenic" effects, i.e. chemical side-effects, is unclear at present. Studies in this laboratory have shown that the carbohydrate content of dinitroaniline treated leaves increase by nearly 80% over control bean leaves. Similar increases in leaf starch content have been reported in leaves adapted to low-water stress (Ackerson, R. C. 1981). Whether or not there is a mild low-water stress induced by dinitroaniline treatment of bean seedlings will be determined by measuring leaf conductances, osmotic potentials, pressure potentials, and abscisic acid content.

Progress: 84/06 to 84/12. The ability of plants to detoxify oxidant species is required to acclimate to a variety of stresses including cold hardening, low-water and ozone stress. These stresses are thought to produce superoxide radicals which then cause physiological injury as well as produce the phytohormone, abscisic acid (ABA). Previous studies have shown that 'Pinto' bean plants subjected to osmotic stresses show an altered sensitivity to subsequent ozone fumigation. The possible relationship between low-water stresses and ozone responses in bean leaves was studied from two perspectives: 1) the origin of ABA during osmotic and low-water stresses; and 2) the mechanism of ABA uptake in plant material. The carotenoid content of leaves subjected to a 15% loss of original fresh weight was examined over a several hour time period when levels of ABA are known to increase dramatically. During the first 30 min following the loss of water from the leaves, there is a 20-30% loss in the total carotenoid content of the seedling leaves. The levels of carotenoid loss were in the range of the amounts of ABA formed under similar conditions of stress. Studies are in progress to determine how the carotenoids are destroyed in the stressed leaves and how the subsequent products may be converted to ABA or related substances. The second area of research has been focussed on ABA uptake into plant cells.

Publications: 84/06 to 84/12
 FONG, F. 1984. Mechanisms of acute and chronic ozone injury. *Trans. Air Pollut. Cont. Assn.* (In press).

FONG, F. and SMITH, J.O. 1984. Leaf carotenoid changes following low-water stress in Zea mays. Plant Physiol. 75S:138.
 POWELL, R.O. and FONG, F. 1984. Effect of fluridone on guard cells. Plant Physiol. 75S:130.

67.055
PLANT DISEASE SURVEY

CRIS0013305

VANALFEN N K; Biology; Utah State University, Logan, UTAH 84322.
 Proj. No.: UTA00034 Project Type: STATE
 Agency ID: SAES Period: 01 JUL 82 to 30 JUN 87

Objectives: To determine the presence, distribution and economic significance of diseases of major crops in Utah. To investigate newly occurring diseases and appraise their future significance. To monitor vegetation for air pollution damage and thereby provide current information concerning the status of air pollution effects on vegetation in Utah.

Approach: Surveys of crop and native plants of Utah will be made throughout the year to assess the plant disease and air pollution damage situation on these plants.

Progress: 84/01 to 84/12. In the past two years there has been an increased diversity of plant diseases seen in Utah compared with what is normally present. This has been the result of the wet weather of recent years. As a result, diseases such as apple scab have been reported in Utah. They have not yet been the cause of economic losses, but their occurrence in a desert is of interest. Economic losses due to foliage pathogens have been noticed in alfalfa where diseases such as downy mildew and common leaf spot have caused loss of leaves prior to harvest in the spring. The stem nematode has also been causing more problem with the first alfalfa crop than is normal. These increased disease problems can be attributed to the wet spring we had this past year. There was little evidence of air pollution damage to plants during 1984. Sensitive plants such as apricot trees show signs of fluoride necrosis when they are located near sources of fluoride emissions, but there was no evidence of SO₂ damage on Guara or other sensitive plants, even near known sources of this pollutant. Permanent plots are being established to monitor the effects of low concentrations of air pollutants on lichens, which are known to be much more sensitive to air pollution than are any of the vascular plants.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

67.056* CRIS0074177
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

WOOLRIDGE G L; Soil Science & Biometeorology; Utah State University, Logan, UTAH 84322.
 Proj. No.: UTA00414 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the productivity of agricultural crops and soils.

Approach: This objective will be achieved by installation and maintenance of a wet-dry deposition collector on the Utah State University campus, as a part of the NC-141/NADP atmospheric chemical deposition network. Analysis of the data from the network will indicate spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in wet and dry deposition. This objective will be approached by cooperative sampling of soil in regions indicated in the analyses stated in Objective 1, where deposition of elements potentially toxic to agricultural crops may occur. If such sampling indicates that toxicity is developing, greenhouse studies using that soil will be initiated in a cooperative program.

Progress: 84/01 to 84/12. Atmospheric wet deposition measurements were completed on a once-a-week basis at the WUT01 deposition site 7 miles southwest of Logan, Utah throughout the year 1984. The pH and electrical conductivity of each sample were measured at the Utah State University laboratory prior to the Central Analytical Laboratory for uniform analyses conforming to the National Atmospheric Deposition Program standards. Initial results of WUT01 sample analyses indicate that (1) CAL measurements of pH generally range from 6.0 to 6.6, with extreme values of 5.0 and 7.3; (2) weekly averages of NO₃ ion concentrations are usually 50% to 100% of SO₄, but on occasion have exceeded the SO₄ ion concentrations. It appears that the WUT01 site would be suitable for use as a "control" site for effects research comparisons.

Publications: 84/01 to 84/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

67.057 CRIS0077872
RESPONSES OF PLANTS TO VISIBLE AND ULTRAVIOLET RADIATIONS

KLEIN R M; Botany; University of Vermont, Burlington, VERMONT 05405.
 Proj. No.: VT00317 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 79 to 30 SEP 84

Objectives: Evaluate role of near-UV and its interaction with visible wavelengths on anthocyanin synthesis. Determine role of UV-activated psoralens in plants. Determine kinetics of green light suppression and orange

light reversal of cell division and differentiation.

Approach: Role of near UV in anthocyanin synthesis to be studied following irradiation of flower petals, apple skins and other plant organs. Effects of near UV on photoaddition of endogenous psoralens to be studied in seeds and cell cultures of umbelliferous plants. Green and orange-red light effects to be examined in seed germination, vascular strand regeneration, cell cultures and flower bud induction.

Progress: 83/01 to 83/12. Cultivars of bean (*Phaseolus vulgaris*) that synthesize ("Burgundy") or do not ("Contender") normally synthesize anthocyanins were grown under ultraviolet light (UV) with filters to determine the effects of UV on growth. Those that formed anthocyanins were not damaged, while those that did not form the screening pigment were damaged. The study was repeated with cultivars of other species. The presence of anthocyanin in leaf and stem epidermal cells is a protectant against UV damage.

Publications: 83/01 to 83/12

KLEIN, R.M., and BLISS, M. 1984. Decline in surface coverage by mosses on Camel's Hump Mountain, Vermont: Possible Relationships to Acidic Precipitation. *The Bryologist*, In press.

MOLONEY, K.A., STRATTON, L.J., and KLEIN, R.M. 1983. Effects of simulated acidic, metal-containing precipitation on coniferous litter decomposition. *Can. J. Bot.* In press.

KLEIN, R.M. 1983. Ecosystems approach to the acid rain problem. In: *Effects of acid rain on vegetation*. (ed.) Linthurst, R.A. Ann Arbor Science Press, MI.

KLEIN, R.M. 1984. Effects of acidity and metal ions on water movement through red spruce. In: *Symposium on acid rain*. (ed.) Adams, D. Pergamon Press, NY.

KLEIN, R.M. 1983. Making apples red with light. *Vermont Science*, 7(2):1,4.

67.058* CRIS0085227
MODE OF ACTION OF SELECTED HERBICIDES AND
HERBICIDE ANTIDOTES

HATZIOS K K; Plant Pathology & Physiology;
 Virginia Poly Inst, Blacksburg, VIRGINIA
 24061.

Proj. No.: VA-0612431 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 81 to 30 SEP 86

Objectives: Study the mode of action of selected herbicides and herbicide antidotes at cellular and subcellular levels to facilitate comprehension of aberrations in physiological functions of selected crop or weed plant species exposed to these chemicals. Study the phytotoxicity of the major metabolites of selected herbicides to determine whether metabolic modification of the parent herbicide molecules by higher plants leads to reduced or increased herbicidal activity.

Approach: Time-course and concentration studies including periods of 30, 60 and 120 min and concentrations of 0, 0.1, 1, 10, and 100 (u)M will be used to examine the effects of these chemicals on photosynthesis, protein, RNA, and lipid synthesis of enzymatically isolated leaf cells or protoplasts of selected crop or weed species. The cells or protoplasts will be incubated with radioactive substrates specific for each metabolic process to be studied. Analyses will include extraction, spectrophotometry and scintillation detection procedures. Interaction studies examining the effects of antioxidants and of the air pollutant oxone (O₃) on the activity of selected herbicides in the presence or absence of specific herbicide antidotes will also be examined.

Progress: 84/01 to 85/09. Studies with safened and unsafened corn showed that in the presence of the safener R-25788 (N,N-diallyl-2,2-dichloroacetamide) the thiocarbamate herbicide EPTC interacted synergistically with the air pollutant ozone and the antioxidants piperonyl butoxide and propyl gallate. Because the antioxidants piperonyl butoxide and propyl gallate act as inhibitors of mixed-function oxidases, it was concluded that R-25788 may protect grass crops against injury from thiocarbamate herbicides by stimulating the metabolic degradation of these herbicides in the protected plants. Naphthalic anhydride (NA) was the most effective of four antidotes tested as safeners for protecting corn against injury from the herbicide isouron. Cyometrinil, CGA-93194 alpha-(1,3-dioxolan-2-yl-methoxy-imino)-benzeneacetoneitrile, and R-25788 were ineffective as protectants of corn against this herbicide. NA and seven of its structural analogues applied as seed dressings of 0.5 and 1.0% by seed weight offered satisfactory protection to 'XL72AA' corn hybrid against injury from the herbicide EPTC. These analogues included the compounds: acenaphthenequinone, 4-amino-1,8-naphthalic anhydride, 1,4,5,8-naphthalenetetracarboxylic dianhydride, 1,8-naphthalimide, 4-chloro-1,8-naphthalic anhydride, diphenic anhydride and phthalic anhydride. The same antidotes antagonized significantly the EPTC activity on 'XL67' corn hybrid but the protection offered was partial and agronomically important.

Publications: 84/01 to 85/09

HATZIOS, K. K., 1983, Interactions of the herbicides EPTC and EPTC plus R-25788 with ozone and antioxidants in corn, *J. Agric. Food Chem.* 31:1187-1191.

HENRY, W. T. and HATZIOS, K. K., 1985, Interactions between the herbicide isouron and selected antidotes on two corn hybrids, *Cereal Res. Comm.* 13:000-000 (In press).

HATZIOS, K. K. and ZAMA, P., 1985, Physiological interactions between the herbicide EPTC and selected analogues of the antidote naphthalic anhydride on two hybrids of corn, *Pestic. Sci.* 16:000-000 (In press)

67.059* CRIS0069843
EFFECT OF AIR POLLUTANTS ON GROWTH AND YIELD OF FOREST TREES, ORNAMENTALS AND FIELD CROPS

MOORE L D; SKELLY J M; Plant Pathology & Physiology; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
 Proj. No.: VA-0202390 Project Type: STATE
 Agency ID: SAES Period: 01 JAN 76 to 30 SEP 82

Objectives: Evaluate the impact of air pollution found in Virginia on forest trees, woody ornamentals, and certain field crops. Determine how air pollution affects certain chemical constituents of plants. Develop practical measures of alleviating plant injury by cultural or genetic methods.

Approach: Selected species, cultivars and/or hybrids will be studied under field and controlled conditions. The effect of ambient and controlled levels of pollutants on growth and development will be determined. Radial increment growth studies and the development of a bioindicator system will be used to study pollution abatement programs. Selected plants will be assayed for certain chemical constituents. The influence on N, P, K, and Ca levels on the sensitivity of plants to pollutions will be ascertained.

Progress: 82/01 to 82/12. Five air pollution monitoring sites were maintained on the Blue Ridge and Appalachian Mountains of Virginia. Pollution intensity was determined over a 5-year period and correlated with damage to white pines. Significant reduction in foliar biomass of plants grown in non-filtered chambers at the sites showed that low levels of pollutions were detrimental. Ozone and sulfur dioxide tolerant plant material of azalea, rhododendron, white pine, loblolly pine and tobacco cultivars, lines and/or hybrids was identified. Studies of the importance of mineral nutrition in altering the sensitivity of tobacco and whitepine to ambient oxidant levels showed that N, P and Ca could be used to reduce pollution sensitivity. The use of specific herbicides to reduce the sensitivity of tobacco transplants to oxidants has been very successful. Investigations of the effects of pollution on numerous chemical constituents as well as plant biomass showed the importance of subclinical levels of pollution on tobacco production in Virginia. Results of this project are now being incorporated into agricultural practices in Virginia.

Publications: 82/01 to 82/12

- BENOIT, L. F.. and SKELLY, J. M.. and MOORE, L. D.. and DOCHINGER, L. S., 1982, Radical growth reductions of *Pinus strobus* L. correlated with foliar ozone sensitivity., Can. J. Forest Res. 12:673-678.
 REILLY, J. J.. and MOORE, L. D., 1982, Influence of selected herbicides on ozone injury in tobacco (*Nicotiana tabacum*).. Weed Sci. 30:260-263.
 DUCHELLE, S. F.. and SKELLY, J. M.. and CHEVONE, B. I., 1981, Oxidant effects on forest tree seedling growth in the Appalachian Mountains., Soil, Water, Air Pollut. 18:363-365.

PHILLIPS, S. O.. and SKELLY, J. M.. and BURKHART, H. E., 1977, Inhibition of growth in asymptomatic white pine exposed to fluctuating levels of air pollution., Phytopathology 67:721-725.
 TREVATHAN, L. E.. and MOORE, L. D., 1981, A study of calcium fertilization on weather fleck and chemical composition of flue-cured tobacco., Tobacco Sci. 25:102-105.

67.060 CRIS0089153
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIAL

WINNER W E; CHEVONE B I; Plant Pathology & Physiology; Virginia Poly Inst, Blacksburg, VIRGINIA 24061.
 Proj. No.: VA-622491 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: A large network of researchers is cooperating to characterize chemical deposition from the atmosphere and assessing its effects in North America. This network consists of 168 scientists in 11 state and federal agencies and more than 20 universities. VPI & SU will contribute to this network by: serving on the Effects Research Committee, operating two stations for collecting chemicals deposited from the atmosphere, and developing experiments to determine the effects of these chemicals on plants.

Progress: 84/01 to 85/09. Samples of wet and dry deposition were continuously collected and sampled weekly at the Horton Center located on Salt Pond Mountain, VA. The samples were analyzed for pH and concentrations of Ca, Mg, K, Na, NH₄, NO₃, Cl, SO₄, and PO₄ ions. All analytical procedures followed protocol outlined by the National Atmospheric Deposition Program. The pH of rainfall at this station ranged from 3.9 to 6.3 and the mean was 4.5. SO₄ and NO₃ ions were associated with low pH values indicating air pollution emissions were influencing rainfall chemistry. These data show no long-term trends in rainfall chemistry at this site. Analysis showed statistical variance in chemical parameters is large for samples collected over a year and indicates that sampling over periods of years will be required to detect whether chemical changes are occurring in rain. Rainfall chemistry data were used to mix a simulated rainfall solution representing industrial rain. These solutions,

when compared to solutions representing pristine rain, altered growth rate and form of radishes in laboratory/greenhouse experiments. Field and laboratory experiments showed deciduous tree canopies buffer precipitation pH to values between 5.2 and 5.8. Throughfall chemistry differs from rainfall chemistry because of both washing of leaf surfaces and leaching of ions from the leaf mesophyll.

Publications: 84/01 to 85/09

- OLSON, R. L., JR. and WINNER, W. E., 1985, Effect of concurrent ozone and acid rain treatments on radish growth, Preliminary results, *Phytopathology* 77:627.
- LEININGER, T. D. and WINNER, W. E., 1985, A comparison of rainfall and throughfall chemistry on two forested sites differing markedly in soil fertility, *Phytopathology* 75:626-627, abstract.

67.061* CRIS0044490
SOIL AND WATER MANAGEMENT SYSTEMS FOR RECLAMATION OF DISTURBED LAND IN APPALACHIA

BENNETT O L; BOYER D G; JONES J N; USDA
 Agricultural Research Service, Beckley, WEST VIRGINIA 25801.
 Proj. No.: 1932-20770-002-00D
 Project Type: INHOUSE
 Agency ID: ARS Period: 12 MAY 78 to 30 SEP 83

Objectives: Develop reclamation and management practices for strip mines and other disturbed lands to optimize desirable plant growth under stress environments and minimize environmental damage, especially to the hydrology and water quality of the area.

Approach: Work will involve laboratory, growth chamber, greenhouse, and field studies to evaluate chemical, physical, and environmental factors that limit stabilization and reclamation of disturbed land areas. Specific investigative parameters will include hydrologic factors, water quality, plant growth and composition, microbiological populations and changes with treatments, fertilization and liming comparisons, use of domestic and industrial waste materials to reduce acidity and improve soil condition, and ways to avoid toxic trace elements in such wastes.

Progress: 83/01 to 83/12. Performance of yearling steers grazing forages grown on reclaimed strip mined land and treated with fluidized bed combustion residue (FBCR) produced gains equal to those from animals grazing on surface mine land treated with agricultural limestone. The FBCR is a granular material resulting from burning coal in a combustion chamber along with finely ground limestone to reduce sulfur and nitrous oxide emissions which are major sources of acid rain. Data indicates that FBCR can be substituted from limestone for correcting subsoil acidity without having any detrimental effect on the grazing animal. Agricultural use of this material may provide a convenient way of disposing of the waste and providing needed plant nutrient sources for agriculture. In other studies, the effects of revegetation and

management practices on water quality on reclaimed surfacemined lands are being studied. The effects of grazing and fertilization programs on effluent quality from reclaimed mine lands will improve our understanding of post mining land use and eliminate water quality problems. The topographic and microclimatic effects on the soil moisture balance of a Central Appalachian surface coal mine indicates that moisture relations can vary widely in mountainous terrain due to slope, exposure, and elevation.

Publications: 83/01 to 83/12

- MENSER, H.A., WINANT, W.M., and BENNETT, O.L. 1983. Spray irrigation with landfill leachate. *Biocycle*, May-June 1983, pp. 22-25.
- GHAZI, H.E., SINGH, R.N., KEEFER, R.F., and BENNETT, O.L. A comparison of level methods for extracting available P from mine soils treated with fly ash and rock phosphate. Presented at NE Branch Am. Soc. of Agron. Mtg.
- BOYER, D.G. 1983. Relation of Surface Runoff Quality to Precipitation Quality on a Surface Coal Mine. Proceedings, National Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation, Lexington, KY. Nov. 29-Dec. 2, 1983.
- KEEFER, R.F., SINGH, R.N., BENNETT, O.L., and HORVATH, D.J. 1983. Chemical composition of plants and soils from revegetated mine spoils. Presented at Symposium on Surface Mining, hydrology, Sedimentology, and Reclamation.

67.062* CRIS0044482
SOIL AND WATER MANAGEMENT SYSTEMS FOR EFFICIENT CROP PRODUCTION IN APPALACHIA

BENNETT O L; LEGG T D; PERRY H D; USDA
 Agricultural Research Service, Beckley, WEST VIRGINIA 25801.
 Proj. No.: 1932-20780-001-00D
 Project Type: INHOUSE
 Agency ID: ARS Period: 12 MAY 78 to 20 JUN 83

Objectives: Develop soil, water, and plant management systems for forage, row and specialty crops on the diverse soil resource of the Appalachian region.

Approach: Laboratory, greenhouse, growth chamber, and field studies will be integrated to evaluate fertilizer amendments, use of domestic and industrial waste materials, biological nitrogen fixation, no-tillage production management systems and species for efficient use of naturally occurring plant nutrients for crop production and plant quality.

Progress: 81/05 to 83/05. Subsoil acidity can be corrected by application of large amounts of organic matter containing excessive amounts of calcium and magnesium. Organic matter proved to be an effective source of ligands for chelation and movement of calcium and magnesium into acid subsoils for replacement of high soil aluminum. Sulfur treatments can have a marked effect on

efficiency of mineral utilization and protein synthesis in the plant metabolism system. Several studies have demonstrated that conservation tillage can increase yields, water use, and fertilizer use efficiency. Corn can be grown using no-tillage systems where sod regrowth is controlled by use of herbicides. Brome, orchard, and fescue grasses proved to be satisfactory for use with the "sleeping" sod no-till technique. Studies with N15 have shown a higher rate of soil nitrogen mineralization under no-till cropping systems than for conventional tillage. Composition of no-till corn plants indicate a higher concentration of P., K., Mn., Zn., and a lower concentration of Fe., Al., Mg., and N. than in the conventionally tilled corn plants. Soil moisture under no-tillage was always higher than for tilled areas. No-till production techniques were demonstrated for potatoes, tomatoes, sweet corn, string beans, and for interseeding various legumes for reclamation of pasture areas.

Publications: 81/05 to 83/05

- HERN, J.L. 1978. Elemental analysis in agriculture using inductively coupled plasma-atomic emission spectroscopy. Fifth Ann. Mtg. Federation Anal. Chem. and Spec. Soc.
- HERN, J.L. and STROHL, J.H. 1978 Modified graphites for chelation and ion exchange. Anal. Chem. 50:1954.
- BENNETT, O.L., STOUT, W.L., HERN, J.L. and SIDLE, R.C. 1978. Potential agricultural uses of fluidized bed combustion waste. Proc. 5th Nat. Conf. on Energy and the environment.
- HERN, J.L., STOUT, W.L., SIDLE, R.C. and BENNETT, O.L. 1978. Characterization of fluidized bed combustion waste: Composition and variability as they relate to disposal on agricultural lands.
- BENNETT, O.L., REID, R.L., WHITSEL, T.J., MITCHELL, D.M., STOUT, W.L., HERN, J.L. and MAY, D.L. 1982. Animal feeding trials using feed and food produced with FBCR. Proc. of 7th Intl. Conf. on FBC. Vol. 1. pp. 559-566.

67.063* CRIS0089148
CHEMISTRY OF ATMOSPHERIC DEPOSITION--EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

BOCKHEIM J G; Soil Science; University of Wisconsin, Madison, **WISCONSIN** 53706.
 Proj. No.: WISO2759 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographic and temporal trends in the chemical climate of North America; and assess the effects of atmospheric deposition on the following.

Approach: Cooperate with the Wisconsin Department of Natural Resources (WDNR) in collecting, characterizing, and processing precipitation data at Rhinelander, WI and Spooner, WI; cooperate with WDNR and the U.S. Geological Survey in an effects research

program, including effects on forests, soils, water quality, and aquatic ecosystem through biogeochemical studies.

Progress: 84/01 to 84/12. The National Atmospheric Deposition Program (NADP) (IR-7) is responsible for collecting and analyzing wet and dry deposition at 150 sites across the U.S. Wetfall collections are made on a weekly basis and dry fall on a biweekly basis. Field measurements include pH, electroconductivity, and volume. Laboratory measurements include pH, conductivity, Ca, Mg., K, Na, NH(4), NO(3), C1, SO(4), and PO(4). Three stations are located in Wisconsin, including Trout Lake in Vilas County, Spooner in Washburn County, and Lake Dubay in Portage County. The Aerochem Metric wet/dry collector at Trout Lake was purchased by the University of Wisconsin Agricultural Experiment Station. Mr. R. Becker of the Wisconsin Department of Natural Resources is responsible for the collections. The following summary is for the 1982 calendar year. Forty-four collections were made over the 12-month period. Total precipitation for the period was 959 mm, which is about 18% above the 30-year average. Wetfall pH ranged from 4.07 to 6.82 and averaged (unweighted mean) 5.0. The dominant cation in wetfall was H ion, followed by NH(4), Ca, Mg, Na, and K. Sulfate was the dominant anion, followed by NO(3), C1, and PO(4). The cation /anion balance was 1.0. The largest concentration of Ca, NO(3), and SO(4) occurred during the period 5/25 to 6/1/82.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

67.064 CRIS0047267
ECONOMIC ASSESSMENT OF CROP LOSSES FROM AIR POLLUTANTS

ADAMS R M; HECK W W; Agri Economics; University of Wyoming, Laramie, **WYOMING** 82070.
 Proj. No.: 7010-20790-010-A(1)
 Project Type: COOPERATIVE AGREE.
 Agency ID: ARS Period: 11 AUG 81 to 30 SEP 84

Objectives: Develop a conceptual framework for assessing the economic costs of air pollution to crop production. Compile economic and physical data to implement the assessment approach.

Approach: Conduct a Workshop whose participants will aid in the construction of the conceptual framework. Available data bases will be entered to develop needed economic and physical data for the economic assessment. Crop yield data, as related to pollution dose, will be obtained from the National Crop Loss Assessment Network's field sites in different regions of the country. Preliminary work will be done with yield data obtained from literature searches.

Progress: 84/01 to 84/12. Progress in 1984 was highlighted by the completion of a national economic assessment of the effects of ozone on U.S. agriculture. This assessment was the result of interdisciplinary cooperation between economists, plant scientists, meteorologists, and others who worked in the NCLAN program.

Specifically, in 1984 the response data on crop yields to ozone generated by the plant scientists were used in an economic model of U.S. agriculture that had been constructed in 1983. This economic model, when combined with the crop yield-ozone information from the response functions was used to measure the economic consequences of changes in ozone pollution on consumers and producers of agricultural commodities. This report was published by U.S. EPA and will be used in evaluating the efficiency of changes in current secondary ambient air quality standards for ozone. The output from this report can provide a general impression of the impact of ozone on U.S. agriculture and thus can be used to compare such pollution effects with other sources of agricultural loss.

Publications: 84/01 to 84/12

- ADAMS, R.M. and MCCARL, B.A. 1985. Assessing the Benefits of Alternative Oxidant Standards on Agriculture: A Role of Response Information. J. Environ. Econ. and Manag. (In Press).
- ADAMS, R.M., CROCKER, T.D., and KATZ, R.W. 1985. The Adequacy of Natural Science Information in Economic Assessments of Pollution Control: A Bayesian Methodology. Review of Economics and Statistics (In Press).
- ADAMS, R.M., HAMILTON, S.A. and MCCARL, B.A. 1984. The Economic Effects of Ozone on Agriculture. USEPA, Office of Research and Development. Research Monograph. EPA-600/3-84-90.
- ADAMS, R.M., HAMILTON, S.A. and MCCARL, B.A. 1985. An assessment of the economic effects of ozone pollution on U.S. Agriculture. J. Air Pollut. Contr. Assoc. (Unpub.)
- ADAMS, R.M., HAMILTON, S.A., and MCCARL, B.A. 1985. The benefits of air pollution control to U.S. Agriculture: Methodological and policy issues. Amer. J. Agric. Econ. (Unpub.).

CM 68 ANIMALS VERTEBRATES - NOT COMMODITY ORIENTED

68.001* CRIS0090116
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

BOYD C E; Agricultural Exper. Station; Auburn University, Auburn, ALABAMA 36830.
Proj. No.: ALAO0587 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints and other protective coatings, and other materials in machinery or structure.

Approach: Small amounts of several types of surface soils will be confined in various kinds of containers in the laboratory. Rain water, representing different degrees of acidification, will be passed over, passed through, or agitated with the soils for different lengths of time. The changes of pH and alkalinity of the water will be measured. Ponds will be treated with hydrated lime and the residual effect of the lime in neutralizing acidity will be ascertained. The benefit of liming to fish and other aquatic life will be considered.

Progress: 84/01 to 84/12. Ponds were treated with sulfuric acid to produce different levels of alkalinity (three replications for each alkalinity value) and fish production was determined. All ponds were fertilized at same rate, but primary productivity decreased with decreasing alkalinity. The best fish production was achieved at 20 mg/l of alkalinity ($P < 0.05$). Production of sunfish did not differ significantly at alkalinity treatments of 1, 3, 5, and 8 mg/l.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

68.002* CRIS0074466
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

BURGY R H; MYRUP L O; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616.
Proj. No.: CA-D*-LAW-3619-RR Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 30 SEP 83

Objectives: Establishing an Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Developing optimum procedures for collecting precipitation (regular timed sampling and event sampling) and dry particulate matter (open containers, air-filtration collectors and biological

collectors). Determining the stability of certain constituents of precipitation during collection, transport and storage prior to analysis. Investigating the transport and transformations of atmospheric constituents. Organizing and coordinating research is the SAES, FS and other research institutions and agencies on the effects of changes in atmospheric deposition.

Approach: For all objectives listed, utilizing a network sampling station and specifications developed by the Regional Project, the data collection, processing analysis and interpretation will be adapted to project requirements. Special studies are to be devised in concert with project subcommittee coordination.

Progress: 79/09 to 83/09. The data acquisition site in the National Atmospheric Deposition Program has been operational since the Fall of 1979. During the first three years of operation only the rainfall season collections were made in the period of September through May. In 1982, the project operation was made to conform to the NADP standards and schedule with full seasonal data collection made weekly throughout the year. During the five years of records acquired at the station a trend is observable in the measured hydrogen ion concentration (pH) of sampled rainfall, tending to become more neutral with pH approaching 5.6. Occasional samples are measured with both higher and lower pH values. Improvement in the station operating procedures and in the handling and processing both in field and laboratory may account for some reduction in the occurrence of low pH values. Other factors may include improved environmental conditions upwind from the site due to reduced emissions of $\text{NO}(x)$ compounds for metropolitan areas and possibly to general shifts in weather phenomena transporting the precipitation products into the region. Based on the record of the site, a general conclusion may be indicated toward low acidic precipitation input in that area of California. The project has been replaced by Inter-Regional Project IR-7, effective October, 1983.

Publications: 79/09 to 83/09
NO PUBLICATIONS REPORTED THIS PERIOD.

68.003 CRIS0075939
PULMONARY EFFECTS OF ENVIRONMENTAL OXIDANT POLLUTANTS

DUNGWORTH D L; TYLER W S; GILLESPIE J R; Pathology; University of California, Davis, CALIFORNIA 95616.
Proj. No.: CALV-P-500 Project Type: STATE
Agency ID: CSVM Period: 01 JAN 77 to 30 DEC 81

Objectives: Test effects of chronic exposure to ambient levels of ozone in experimental animals. Obtain dose-response data relevant to air quality criteria. Test hypothesis concerning mechanisms involved in production of resulting pulmonary disease. Provide insight into pathogenesis of chronic obstructive pulmonary disease in man.

Approach: Rats and monkeys, primarily, will be exposed for periods of 3-24 months to ozone in concentrations within the 0.2 to 0.8 ppm range. A multidisciplinary group will make integrated biochemical, bacteriological, physiological and pathological evaluation of effects.

Progress: 83/01 to 83/12. Two important observations have been confirmed concerning the chronic effects of ozone. Their implications and mechanisms will be explored. First, inflammatory cell components, epithelial changes, and interstitial fibrosis do not have the same time-response relationships and therefore have more complex interactions than previously thought. Second, some components of chronic lesions persist following the end of ozone exposure and might even lead to progressive changes. Evidence for progression in postexposure periods has been obtained from pulmonary function studies in the monkeys in experiments using young rats. This might, in part, be due to remodeling of the respiratory bronchiole (transitional) region which we have found to occur in both monkey and rats. A finding of major importance is the synergism between ammonium sulfate particles and ozone or nitrogen dioxide. Biochemical and morphometric evaluations reveal addition of a respirable aerosol of ammonium sulfate (5 mg/m³) to ozone exposure (0.64-1.2 ppm) causes an approximate doubling of the amount of collagen synthesis and fibroblast proliferation compared to ozone alone.

Publications: 83/01 to 83/12

- BOLTON, D.C., ZEE, Y.C., and OSEBOLD, J.W. 1982. The biological effects of ozone on representative members of five groups of animal viruses. *Environmental Research* 27:476-484.
- CHRISTMAN, C.A. and SCHWARTZ, L.W. 1982. Enhanced phagocytosis by alveolar macrophages induced by short-term ozone insult. *Environmental Research* 28:241-250.
- ETCHISON, J.R., KAIZU, T., FRATES, R.C., JR., LAST, J.A. and CROSS, C.E. 1982. Sodium ion transport and airway mucus secretion. The effect of the sodium ionophore monensin on glycoprotein secretion by cultured rat trachea.
- JACKSON, A.C., TABRIZI, M., and MARGOLIS, D.L. 1982. Effects of branching angle on oscillatory resistances of bifurcations. *Physiologist* 25:211.
- JACKSON, A.C. and WATSON, J.W. 1982. Oscillatory mechanics of the respiratory system in normal rats. *Respiration Physiology* 48:309-322.

88.004 CRIS0077558
HEALTH EFFECTS OF GASEOUS AND PARTICULATE EFFLUENTS OF COAL UTILIZATION

TYLER W S; DASGUPTA P K; GILLESPIE J R;
 Primate Research Cntr; University of California, Davis, CALIFORNIA 95616.
 Proj. No.: CALV-RP-1112 Project Type: STATE
 Agency ID: CSVM Period: 07 DEC 78 to 30 APR 82

Objectives: Determine the effects and mechanisms of effects of sulfite and nitrites on the respiratory system and the character of responses to adaptation at recovery.

Approach: Expose rodents, dogs or monkeys to varying levels of transition metal sulfites and on "high ambient" concentrations of sulfites and nitrites to different animal species over varying lengths of time and compared to oxidation states of sulfur and nitrogen. The biochemical, physiological, and pathological alterations will be recorded.

Progress: 82/01 to 82/12. The overall objective of this multidisciplinary project was the evaluation of the long-term human health effects of effluents from coal utilization by large electricity generating plants. These effluents are a variable, complex, interacting mixture of gases and particles. Major effort was devoted to the generation and monitoring of appropriate pollutants. These efforts were successful and reported in the open literature. A new method for determination of SO₂ has been developed which may replace methods currently used for evaluation of air quality. Another study supported by this contract concerns effects of mixtures of ozone and various sulfur oxides which may be more toxic than either component. Pulmonary alveolar macrophages are commonly lavaged from human beings and laboratory animals for a variety of studies, including effects of power plant effluents. Questions arise as to whether the lavaged macrophages are representative of the lung's macrophage population. Electron microscope morphometry indicated that ozone exposure activated and increased endocytosis in both lavaged and in situ macrophages. In situ macrophages had a greater number of cell compartments significantly changed and the degree of statistical significance was greater than in lavaged macrophages in both control and exposed rats.

Publications: 82/01 to 82/12
 NO PUBLICATIONS REPORTED THIS PERIOD.

68.005 CRIS0083752
HEALTH EFFECTS FROM THE INHALATION OF OXIDANT AIR POLLUTANTS AS RELATED TO THE IMMUNE SYSTEM

OSEBOLD J W; ZEE Y C; Veterinary Microbiology; University of California, Davis, CALIFORNIA 95616.
 Proj. No.: CALV-AB-122-131 Project Type: STATE
 Agency ID: CSVM Period: 01 OCT 80 to 30 SEP 85

Objectives: To investigate the mechanisms by which ozone and sulfuric acid mist may exacerbate the syndrome of extrinsic asthma. To determine how ozone and sulfuric acid mist may alter the severity and pathogenesis of influenza virus infection. To determine whether lung changes from the inhalation of air pollutants are associated with autoimmune phenomena.

Approach: Specific pathogen-free mice are exposed to various levels of oxidant pollutants and/or allergen or influenza virus aerosols.

Various parameters of immunological responses, biological and histological alterations and influenza virus pathogenesis as determined by immunofluorescence are measured and compared.

Progress: 84/01 to 84/12. A study was performed on guinea pigs to determine allergic lung reactivity from inhaled allergens. Animals were housed in stainless steel environmental chambers and divided into subgroups. Aerosolized ovalbumen was used as the allergen and guinea pigs were sensitized by allergen inhalation once every ten days for a series of four exposures. Each aerosolization was preceded by a four-day period of continuous exposure to 0.25 ppm of ozone for half of the animals. The same aerosolization schedule was followed for guinea pigs held in filtered ambient air throughout the trial. Sensitization was tested by the inhalation of concentrated allergen, which was referred to as the provoking aerosol. This experiment has now been completed, and the results are being analyzed. The adjuvant effect from a commercially available diphtheria/tetanus/pertussis (DTP) vaccine was used in an experiment studying allergic enhancement by ozone inhalation. Previous work has shown that the injection of *Bordetella pertussis* cells increased the numbers of sensitized animals when the mice were allowed to inhale an allergen. Mice were divided into eight test groups, including a group receiving a human equivalent dose of pertussis cells, commonly used in childhood immunizations. Ozone exposure was at the level of 0.18 ppm. Systematic anaphylaxis was the test used for determining allergic sensitivity in the mice. This experiment has now been completed and the results are to be analyzed.

Publications: 84/01 to 84/12

NO PUBLICATIONS REPORTED THIS PERIOD.

68.006* CRIS0087502
BOUNDARY LAYER PHENOMENA & ACIDIC PRECIPITATION

PAW-U K T; Agronomy; Purdue University, West Lafayette, INDIANA 47907.
Proj. No.: IND050079 Project Type: HATCH
Agency ID: CSRS Period: 01 JUN 82 to 01 MAY 84

Objectives: To analyze and identify the importance of air flow in the vicinity of vegetation, and its interaction with the air flow in the atmospheric boundary layer. To analyze and identify the nature of the interaction between biota and the atmospheric boundary layer, and to identify key variables in the interaction.

Approach: Theoretical, field, and laboratory research will be conducted to determine the patterns and turbulent nature of clean or particle-laden air flow in the vicinity of vegetative elements. The patterns will be analyzed in terms of interactions between the biota and atmosphere; the transport of such material as sulfur compounds and their effect on acidic precipitation will be of special interest.

Progress: 83/01 to 83/12. The estimation of leaf diffusive resistances as a function of temperatures of coated and uncoated leaves was modeled; it was found estimations with the energy budget method were as accurate as porometrically derived values. Theoretical work was also done on the occurrence of equal leaf and air temperatures. The nature of pollen trajectories in the vicinity of ovulate cones was examined with the aid of videotape analysis, and it was determined that many factors increase net deposition of pollen grains on the ovulate cones. It was determined, however, that the von Karman vortex formation behind ovulate cones was probably not a significant phenomenon in terms of evolutionary pressure. Acidic precipitation studies continued at Purdue. Very low pH values were measured for some precipitation (less than 3.5), but no values higher than 5.6 were reported. Theoretical work showed that under certain conditions, a single power plant of the 60 MW size could cause significant acidic precipitation from over 100 to 300 km downwind. The model used was not valid for greater distances, although it is possible the contribution would also be significant at those locations.

Publications: 83/01 to 83/12

- PAW U, K. T. 1984. A theoretical basis for the leaf equivalence point temperature. Accepted by *Agricultural Meteorology*.
ANDRESEN, J. and PAW U, K. T. 1984. Modeling of SO₂ emissions and acidic precipitation at mesoscale distances. Accepted by *Electric Utilities Research Conference*, Chicago, 1984.
NIKLAS, K. J. and PAW U, K. T. 1983. Conifer ovulate cone morphology: implications on pollen impaction patterns. *Amer. J. Botany* 70:568-577.
PAW U, K. T. 1983. Rebound of particles from natural surfaces. *J. Colloid Interface Science*. 93:442-452.
PAW U, K. T. 1983. A universal model for entrainment processes. Accepted by *Proceedings, 4th Conference on Precipitation Scavenging Dry Deposition and Resuspension*, 29 Nov.-Dec. 1982. (Refereed proceedings).

68.007* CRIS0088960
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

FEAGLEY S E; Agronomy; Louisiana State University, Baton Rouge, LOUISIANA 70803.
Proj. No.: LAB02307 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: Discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. Assess the effects of atmospheric deposition on the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; the chemical composition of surface and ground waters.

Approach: These objectives will be achieved by further developing and maintaining the NC-141/NADP atmospheric chemical deposition and related local networks. Estimates of atmospheric sources of nutrients for growth of agricultural crops and forest trees will be taken. Contribution of atmospheric sulfur to growth of cultivated and non-cultivated crops. Foliar uptake of nutrient and toxic metals by forest trees and orchard, field, forage and vegetable crops. Identification of regions that are sensitive and soil factors contributing to sensitivity to acid precipitation. Influence of precipitation chemistry on mineral weathering, colloid chemistry, clay development, and suspension potential of soils. Long-term and short-term changes in atmospheric deposition and mobilization of heavy metals.

Progress: 84/01 to 84/12. The total amount of rainfall at Homer, New Iberia and Franklinton through 12/19/84 was 54.93, 60.36 and 56.12 inches, respectively. The range in pH for each site respectively was 4.95 to 4.07, 5.56 to 4.20 and 5.66 to 4.01. The range in EC was 25.7 to 3.9, 40.0 to 4.2 and 40.0 to 8.5 $\mu\text{S}/\text{cm.} (+)$ Other parameters being monitored are $\text{NO}_3(3)$, $\text{PO}_4(4)$, $\text{SO}_4(4)$, Cl , Ca , Mg , K , Na and $\text{NH}_4(4)$. Four ponds are being monitored weekly by taking surface samples. All parameters mentioned above are being done on the samples as well as temperature. A lake sampler is being tested to sample the lake from the shore at various depths.

Publications: 84/01 to 84/12
FEAGLEY, S.E. and CREMERS, R.B. 1984. Acid rain and its accumulation: A problem in Louisiana? La. Agric. 27:4, 5 and 24.

68.008* CRIS0086840
ATMOSPHERIC DEPOSITION OF ACID RAIN AND MINERAL ELEMENTS IN LOUISIANA

JONES J P; FEAGLEY S E; Agronomy; Louisiana State University, Baton Rouge, LOUISIANA 70803.
Proj. No.: LAB02249 Project Type: HATCH
Agency ID: CSRS Period: 01 MAR 82 to 04 JAN 83

Objectives: Establish atmospheric deposition collection sites for wet and dry precipitation in selected areas and provide appropriate data in cooperation with the National Atmospheric Deposition Program (NC-141).

Approach: Monitor precipitation from the atmosphere in Louisiana to include: pH, wet and dry deposition of sulfur, nitrogen and heavy metals. Determine the effect of acid precipitation and the deposition of sulfur and heavy metals on agricultural crops and livestock.

Progress: 82/03 to 83/01. Project H2249 on Nc0141 is being terminated and replaced by H2307 on IR-7 project. Three NADP sites were established in Louisiana. These were located at Homer, Iberia and Franklinton. The Homer and Iberia sites were put into operation on November 16, 1982. Franklinton will be started at a later date because of electrical

difficulties. The pH values ranged from 4.78 to 5.18 at Homer and 4.50 to 5.76 at Iberia. The precipitation weighted averages from 11/16/82 to 1/4/83 were 5.01 at Homer and 5.44 at Iberia. The E.C. values ranged from 1.2 to 13.5 $\mu\text{hos.}/\text{cm.}$ at Homer and 3.8 to 15.2 $\mu\text{hos.}/\text{cm.}$ at Iberia. The precipitation weighted averages were 8.0 and 5.5 $\mu\text{hos.}/\text{cm.}$ at Homer and Iberia, respectively.

Publications: 82/03 to 83/01
NO PUBLICATIONS REPORTED THIS PERIOD.

68.009 CRIS0096483
EFFECTS OF ACID PRECIPITATION ON SALAMANDER COMMUNITIES IN FOREST WETLANDS OF WESTERN MASS.

GRIFFIN C R; Forestry & Wildlife Management; University of Massachusetts, Amherst, MASSACHUSETTS 01003.
Proj. No.: MAS00055
Project Type: MCINTIRE-STENNIS
Agency ID: CSRS Period: 01 OCT 85 to 30 SEP 88

Objectives: Survey selected forest wetlands of western Massachusetts for salamander species diversity and abundance. Evaluate changes in the acidity of salamander breeding ponds with inputs of rainfall and snowmelt. Assess variations in salamander reproductive success with acidity of water in breeding ponds. Evaluate historical changes in pond chemistry and salamander breeding populations in forest wetlands of western Massachusetts.

Approach: The proposed research will involve surveys of salamander populations and chemical and physical factors in present and historical salamander breeding ponds; measurements of changes in chemistry of selected ponds from late winter through the periods of spawning, embryonic development, and larval growth, in relation to inputs from precipitation and snowmelt runoff; and evaluations of embryonic development in ponds over a range of chemical and physical conditions.

68.010* CRIS0074631
CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

HART J B; Forestry; Michigan State University, East Lansing, MICHIGAN 48824.
Proj. No.: MICL01282-H Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 77 to 28 DEC 84

Objectives: Establishing an Atmospheric Deposition Network to determine special & temporal trends in the supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter deposited in various regions of the United States. Organizing and coordinating research in the SAES, FS, and other research institutions & agencies on the effects of changes in atmospheric deposition on: The productivity of agricultural crops, forests, range lands, wet lands, and surface waters: The

health & productivity of domestic food animals, wildlife, and fish; and the corrosion of metals, painted surfaces, masonry, and other materials in machinery or structures.

Approach: Establishment of two monitoring sites in Michigan. Weekly analysis of collected precipitation & dry particulates. Use trends to find effects on forest growth & reproduction.

Progress: 83/01 to 83/09. Research activities were pursued in this project prior to initiation of Project IR-7. Two wet-dry deposition monitoring sites are maintained as part of the National Atmospheric Deposition Program network and National Trends Network: one at Kellogg Biological Station in southwest lower Michigan; and one at the University of Michigan Biological Station in north central lower peninsula Michigan. Precipitation acidity has ranged from extremes of 3.8 to 7.2 with a normal range of 4.2 to 5.7. Simulated acid precipitation of pH 2.5 and below adversely affected greenhouse germination and survival of jack pine. Foliar necrosis and stem lesions were produced on seedlings grown at pH 3.0 and below. Preliminary results indicate episodic simulated acid precipitation of pH 3.0 has no significant effect on survival, growth, or foliar appearance of one-year old jack pine seedlings or competing species of *Carex* sedge. Interpretation of the monitoring network results using information from previous research indicate that neither the extremes or normal acidity ranges are sufficient to preclude the germination and early development of *Pinus banksiana* on typic Udipsamment soils of the region.

Publications: 83/01 to 83/09

MACDONALD, N.W. 1983. The effects of simulated acid precipitation on regeneration and soils in the Jack pine-Grayling sand ecosystem. M.S. Thesis. Michigan State University, E. Lansing, 189p.

68.011* CRISO078453
CHEMISTRY OF ATMOSPHERIC DEPOSITION - EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

KRUPA S V; Plant Pathology; University of Minnesota, St Paul, MINNESOTA 55108.
Proj. No.: MIN-22-080 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetland and soils.

Approach: This objective will be achieved by further developing and maintaining the NC-141/NADP atmospheric chemical deposition network and related local networks. The Program will determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in both wet

and dry deposition in various regions of the United States. The Program will also describe the atmospheric processes by which essential nutrients, strong acid and acidifying substances, toxic metals, and other beneficial and injurious substances are transferred from various man-made and natural sources through the atmospheric and are deposited on plant, animals, soils and surface waters. The work of this Network will be developed in parallel with the related Canadian Network for Sampling Precipitation (CANSAP).

Progress: 84/01 to 84/12. Chemical characteristics of aerosol and rain samples collected at five sites in Minnesota during the summer of 1982 were generally similar in regard to the relative proportions of major constituents. On a mass basis, sulfate was the predominant component in the fine particle (<2.5 μ m) fraction. The concentrations of crustal materials in both the aerosol and the rain followed a gradient in which concentrations increased with proximity of the sampling site to the prairie. The concentrations of the crustal materials in the aerosols were correlated with their concentrations in subsequent rain, whereas concentrations of other constituents were not significantly correlated between aerosol and rain. Nitrates and crustal materials were removed more effectively by both wet and dry mechanisms than ammonium, sulfate and other constituents occurring predominantly in the fine fraction. The components in the aerosols were divided by factor analysis into: ammonium sulfates, crustal materials.

Publications: 84/01 to 84/12

GUIANG, S.F., KRUPA, S.V. and PRATT, G.C. 1984. Measurement of S(IV) and organic anions in Minnesota rain. Atmos. Environ. 18:1677-1682.
PRATT, G.C. and KRUPA, S.V. 1985. Aerosol chemistry in Minnesota and Wisconsin and its relation to rain chemistry. Atmos. Environ. (In press).

68.012 CRISO093988
MECHANISM OF ACTION OF ENVIRONMENTAL TOXICANTS AND CARCINOGENS

COULOMBE R; Animal Dairy & Vet Science; Utah State University, Logan, UTAH 84322.
Proj. No.: UTA00126 Project Type: HATCH
Agency ID: CSRS Period: 01 OCT 84 to 30 JUN 87

Objectives: To more fully investigate the mechanism of action of environmental toxicants and carcinogens on biological systems. In addition, it is intended to evaluate possible interactions between atmospheric pollutants, specifically oxidants such as ozone and sulfur dioxide, on the action of ubiquitous, agriculturally-important carcinogens, such as aflatoxin B1 and benzo(alpha)pyrene.

Approach: Approach will include investigations of pollutant and carcinogen action in whole animal and tissue culture systems. Laboratory rodents will be exposed to gaseous pollutants in vivo and alterations in carcinogen

metabolism will be assessed in tissue fractions in vitro. Determination of genetic alterations (such as DNA alkylation and strand breakage) will be performed in tissue culture in vitro.

CM 70 RESEARCH EQUIPMENT AND TECHNOLOGY

70.001* CRIS0087192 CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS

TOPDL L E; Environ Monit & Serv Ctr; Rockwell International, Newbury Park, CALIFORNIA 91320. Proj. No.: CALW-RI-NC-141-1 Project Type: STATE Agency ID: OCI Period: 01 OCT 81 to 30 SEP 85

Objectives: Establishing an Atmospheric Deposition Network to determine spatial and temporal trends in the supply of beneficial nutrient elements and potentially injurious substances in precipitation and dry particulate matter deposited in various regions of the United States. Developing optimum procedures for collecting precipitation (regular timed sampling and event sampling) and dry particulate matter (open containers, air-filtration collectors, and biological collectors). Determining the stability of certain constituents of precipitation during collection, transport and storage prior to analysis.

Approach: Network of 19 sites in 17 states in eastern and midwestern U.S. performs daily samplings. Each site has at least one HASL type collector and a weighing bucket rain gauge and measures sample amount, pH and conductivity. Chemical constituents of samples analyzed in lab. Data analysis to be performed.

70.002* CRIS0066897 URBAN AND RURAL ENVIRONMENTAL QUALITY PROTECTION

MYRUP L O; CARROLL J J; COULSON K L; Land, Air & Water Resources; University of California, Davis, CALIFORNIA 95616. Proj. No.: CA-D*-LAW-2973-H Project Type: HATCH Agency ID: CSRS Period: 01 NOV 74 to 30 SEP 84

Objectives: Study the processes determining levels of air pollution. Develop mathematical models of various aspects of the air pollution regime. Improve means for measuring air pollution concentrations. Study the physical and chemical nature of particulates and their effect on atmospheric radiation. Quantify environmental parameters for introduction into the decision-making process.

Approach: The approach will be to make measurements of the amounts and properties of the various pollutants in the atmosphere, as well as their radiative effects, and to utilize these data in arriving at mathematical models of the processes involved.

Progress: 84/01 to 84/12. During the reporting period work continued on the development of improved methodologies to estimate atmospheric particulate transport through the use of principal components analysis. Two techniques were selected for application which use different wind direction variable in an octant-by-octant analysis. The second uses a wind direction pointer and can be used to obtain the fine detail of the wind

direction-aerosol loading relationship. These techniques were applied to a data set taken in the Mojave Desert and the following results were achieved: (1) At the Tahachapi site, we have identified nocturnal transport of lead aerosol from the San Joaquin Valley. (2) At the Palmdale site we also detected nocturnal flow of lead aerosol from the direction of Soledad Canyon. (3) At the Cajon site, we identified a non-stability related lead aerosol stream from the direction of the Cajon pass. (4) In addition to aerosols clearly identified with pollution sources, the air above the desert is occupied by a cloud of aerosols derived from crustal elements and apparently aged pollution aerosols. A field experiment was conducted in the late spring and summer of 1984 utilizing a tethered balloon and data from the UCD-SEMRTS weather station to monitor near ground wind and temperature profiles (alt less than 100m).

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

70.003* CRIS0077142 ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURAL AND FORESTED LAND AND SURFACE WATERS

GIBSON J H; Natural & Environmental Res; Colorado State University, Fort Collins, COLORADO 80523. Proj. No.: COLO2014 Project Type: SPECIAL GRANT Agency ID: CSRS Period: 03 JUL 78 to 30 SEP 80

Objectives: Establish Atmospheric Deposition Network to determine spatial & temporal trends in supply of beneficial nutrient elements & potentially injurious substances in precipitation & dry particulate matter. Determine relative importance of precipitation & dry particulate matter. Develop optimum procedures. Determine stability of collection of precipitation constituents. Investigate transport & transformations. Organize & coordinate research in SAES, FS, & other institutions on the effects of atmospheric deposition on the productivity of agricultural crops, forests, range, wet lands, & surface waters.

Approach: Provide coordination for development of a program nationally to meet objectives including organization of central analytical laboratory & data analysis management service.

Progress: 82/01 to 82/12. Funds made available by the North Central Region of the State Agricultural Experiment Station (NC-141) and the U.S. Department of Agriculture CSRS are combined to support the coordination, data management and publications for the NC-141-sponsored program in atmospheric deposition referred to as the National Atmospheric Deposition Program (NADP). This support has been primarily directed to the establishment and coordination of a national atmospheric deposition monitoring network. Additional support has been obtained from other Federal agencies including BLM, EPA, USGS, USFS and NOAA, and a number of sites are supported by state agencies and private corporations.

Since the beginning of the program in 1978, this monitoring network has expanded to 108 operating sites across the country, including Alaska and American Samoa. In 1983, NADP will become the core of the National Trends Network (NTN) which is being established under the mandated National Acid Precipitation Assessment Plan, with the addition of approximately 40 monitoring sites anticipated by 1984. Data published by the program now includes eight volumes covering data from July of 1978 through December of 1980. In addition, the monitoring data is available on computer tape either from the Natural Resource Ecology Laboratory, Colorado State University, or from the Environmental Protection Agency Data Management System, Research Triangle Park, North Carolina.

Publications: 82/01 to 82/12

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM. 1982.
NADP Instruction Manual: Site Operation.
Beigelow, D.S. (Editor). Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO. 30 pp.

70.004* CRIS0074715
CHEMISTRY OF ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS AND MATERIALS

GIBSON J H; Natural Resource Ecology Lab;
Colorado State University, Fort Collins,
COLORADO 80523.
Proj. No.: CDLO0206 Project Type: HATCH
Agency ID: CSRS Period: 01 DCT 84 to 30 SEP 87

Objectives: Establish and maintain a monitoring station at the CPER within the NADP (IR-7) Atmospheric Deposition Network. Determine spatial and temporal trends in the supply of beneficial nutrients and potential injurious substances in atmospheric deposition. Develop optimum procedures for collecting precipitation and dry particulate matter. Determine the stability of certain constituents of precipitation during collection, transport and storage prior to analysis.

Approach: Establish a collection site on the Central Plains Experimental Range of the USDA/ARS. Investigate appropriate collection procedures for dry deposition. Investigate differences of analytical results for samples analyzed on site and after transport to a central laboratory.

Progress: 83/10 to 84/10. The atmospheric deposition monitoring site on the Central Plains Experimental Range of the U.S. Department of Agriculture (Pawnee Site) represents an important component of the National Atmospheric Deposition Program (NADP) monitoring network - now a 175-station network operated under the direction of an interregional project of the State Agricultural Experiment Stations (Project IR-7). This site has been operational since April of 1979. While data from this site indicates pHs averaging around 5.6, levels of sulfate and nitrate demonstrate a substantial contribution to the sample acidity by anthropogenic sources. The reason that pHs do not range in the low 4s is

because this potential acidity is modified by alkaline soil particulate matter which is washed out with the rain and dissolved in the precipitation samples. This site has been designated as an NTN site for the federal acid rain monitoring program operated by the NADP. Data from this site and other sited in the network are now providing important information for studies such as those associated with the U.S./Canadian Memorandum of Agreement and the development of U.S. policy for the control of acidic deposition. For the first time, atmospheric deposition patterns and acidity can now be evaluated for the entire North American continent. The National Atmospheric Deposition Program network is now the core of the National Trends Network (NTN) established under the National Acid Precipitation Assessment Plan (NAPAP).

Publications: 83/10 to 84/10

GIBSON, J.H. and BARDN, J. 1984. Acidic deposition in the Rocky Mountain region. Proceedings of Sixth High Altitude Revegetation Workshop. In Press.

70.005* CRIS0089822
CHEMISTRY OF ATMOSPHERIC DEPOSITION AND EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, AND MATERIALS

GIBSON J H; Natural Resource Ecology Lab;
Colorado State University, Fort Collins,
COLORADO 80523.
Proj. No.: COL00223 Project Type: HATCH
Agency ID: CSRS Period: 01 DCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: a) the productivity of agricultural crops, forest trees, rangelands, wetlands, and soils; b) the health and productivity of domestic food animals, wildlife, and fish; c) the chemical composition of surface and ground waters; and d) atmospheric visibility and the corrosion of metals, masonry.

Approach: Provide coordination to further develop and maintain the National Atmospheric Deposition Program (NADP) chemical deposition network as well as the NAPAP National Trends Network (NTN).

Progress: 83/01 to 83/12. This project furnished administrative support for research carried on under the IR-7 interregional research project goals stated above.

Publications: 83/01 to 83/12

NO PUBLICATIONS REPORTED THIS PERIOD.

70.006* CRIS0087502
BOUNDARY LAYER PHENOMENA & ACIDIC PRECIPITATION

PAW-U K T; Agronomy; Purdue University, West Lafayette, INDIANA 47907.
 Proj. No.: IND050079 Project Type: HATCH
 Agency ID: CSRS Period: 01 JUN 82 to 01 MAY 84

Objectives: To analyze and identify the importance of air flow in the vicinity of vegetation, and its interaction with the air flow in the atmospheric boundary layer. To analyze and identify the nature of the interaction between biota and the atmospheric boundary layer, and to identify key variables in the interaction.

Approach: Theoretical, field, and laboratory research will be conducted to determine the patterns and turbulent nature of clean or particle-laden air flow in the vicinity of vegetative elements. The patterns will be analyzed in terms of interactions between the biota and atmosphere; the transport of such material as sulfur compounds and their effect on acidic precipitation will be of special interest.

Progress: 83/01 to 83/12. The estimation of leaf diffusive resistances as a function of temperatures of coated and uncoated leaves was modeled; it was found estimations with the energy budget method were as accurate as porometrically derived values. Theoretical work was also done on the occurrence of equal leaf and air temperatures. The nature of pollen trajectories in the vicinity of ovulate cones was examined with the aid of videotape analysis, and it was determined that many factors increase net deposition of pollen grains on the ovulate cones. It was determined, however, that the von Karman vortex formation behind ovulate cones was probably not a significant phenomenon in terms of evolutionary pressure. Acidic precipitation studies continued at Purdue. Very low pH values were measured for some precipitation (less than 3.5), but no values higher than 5.6 were reported. Theoretical work showed that under certain conditions, a single power plant of the 60 MW size could cause significant acidic precipitation from over 100 to 300 km downwind. The model used was not valid for greater distances, although it is possible the contribution would also be significant at those locations.

Publications: 83/01 to 83/12

- PAW U, K. T. 1984. A theoretical basis for the leaf equivalence point temperature. Accepted by Agricultural Meteorology.
 ANDRESEN, J. and PAW U, K. T. 1984. Modeling of SO₂ emissions and acidic precipitation at mesoscale distances. Accepted by Electric Utilities Research Conference, Chicago, 1984.
 NIKLAS, K. J. and PAW U, K. T. 1983. Conifer ovulate cone morphology: implications on pollen impaction patterns. Amer. J. Botany 70:568-577.
 PAW U, K. T. 1983. Rebound of particles from natural surfaces. J. Colloid Interface Science. 93:442-452.

PAW U, K. T. 1983. A universal model for entrainment processes. Accepted by Proceedings, 4th Conference on Precipitation Scavenging Dry Deposition and Resuspension, 29 Nov.-Dec. 1982. (Refereed proceedings).

70.007* CRIS0089150
CHEMISTRY OF ATMOSPHERIC DEPOSITION: EFFECTS ON AGRICULTURE, FORESTRY, SURFACE WATERS, & MATERIALS

HENDERSON G S; Forestry Fisheries & Wildlife; University of Missouri, Columbia, MISSOURI 65211.
 Proj. No.: MO-00163-1 Project Type: HATCH
 Agency ID: CSRS Period: 01 OCT 82 to 30 SEP 87

Objectives: To discover and characterize biologically important geographical and temporal trends in the chemical climate of North America. To assess the effects of atmospheric deposition on the following: The productivity of agricultural crops, forest trees, range lands, wetlands, and soils; the health and productivity of domestic food animals, wildlife, and fish; the chemical composition of surface and ground waters; and atmospheric visibility and the corrosion of metals, masonry and stone, paints, and other productivity coatings, and other material in machinery or structure.

Approach: NADP monitoring stations are presently established at University Forest near Poplar Bluff and at the Ashland Wildlife Area. These collection stations will continue to be operated with samples analyzed to characterize the chemistry of rainfall in Missouri. Additional research will be conducted on soil fertility as affected by acid deposition. Plots which have received quarterly additions of accelerated acid inputs will be used in this study. Base status and nitrogen transformations will be most intensively studied.

Progress: 84/01 to 84/12. Precipitation monitoring at two NADP stations was continued in Missouri. The data from these stations continue to show that Missouri's precipitation is acid with a pH averaging between 4.5 and 4.6. Chemical analyses on the samples further indicate that the precipitation is dominated by sulfate with lesser amounts of nitrate. Soil in plots which have been artificially acidified for the past two years were sampled and subjected to analysis. No significant changes in soil acidity were observed among the different acidity treatments. This experiment is being continued and soil will be sampled again next spring. A major research project designed to evaluate the effects of soil aluminum on tree root growth was installed this year. The study utilizes root ingrowth cores constructed from soil treated as as to create a wide range of extractable aluminum concentrations to quantify root growth changes. The study is being conducted at three sites with three vegetation types: Oak-Hickory in Missouri, Loblolly Pine in Mississippi, and a northern hardwoods - spruce - hemlock mixture in New York.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

70.008 CRIS0089625
**A CONTRIBUTION TO ATMOSPHERIC PARTICLE SOURCE
APPORTIONMENT METHODS BY SCANNING ELECTRON
MICROSCOPY**

JOHNSON D L; School of Biology Chem & Ecolo;
State University of New York, Syracuse, NEW
YORK 13210.
Proj. No.: NYZ-2370-02-007 Project Type: STATE
Agency ID: OCI Period: 01 MAR 82 to 31 AUG 83

Objectives: Formal linkages between atmospheric particle source dispersion and source reception models will be attempted in this project by building a "bridge" from the source receptor side through utilization of some of the unique capabilities of scanning electron microscopy as it related to individual particle characterization.

Approach: The approach will involve a combination of the three types of source-receptor models: chemical element partitioning, compound class partitioning, and particle class partitioning.

Progress: 82/03 to 83/08. ESF participated in the July-August sampling program run by USEPA in Philadelphia, PA. ESF collected 31 soil samples for the study area and designed the sample protocol for collection of 42 road dust samples which were obtained by NSI (Northrup Services Inc.) of Research Triangle Park. We have analyzed all 31 soil samples and sent 14 of them (along with 5 rock specimens) to our cooperating laboratory at South Dakota School of Mines and Technology. Computer programs for individual object vector manipulation have been created and tested. Analysis of ambient samples is still underway. Final results are expected by May 1, 1984 for inclusion in the Quail Roost III Conference.

Publications: 82/03 to 83/08
NO PUBLICATIONS REPORTED THIS PERIOD.

70.009* CRIS0091494
**THE IMPACT OF ACID PRECIPITATION ON PIEDMONT
FOREST SOILS**

VAN LEAR D H; Forestry; Clemson University,
Clemson, SOUTH CAROLINA 29631.
Proj. No.: SCZ01806-FR Project Type: STATE
Agency ID: OCI Period: 01 AUG 82 to 30 JUN 85

Objectives: To determine the importance of anthropogenic inputs of acidity, natural internal production of acidity, and tree harvesting techniques to nutrient losses from a Piedmont forest soil. To evaluate present and potential future adequacy of soil nutrients for sustained forest productivity based on measurement of present nutrient pools in forests, nutrient status of soils, nutrient losses by acid deposition, natural internal processes, and tree harvesting.

Approach: Precipitation and throughfall will be collected by 10 open-bucket collectors in and adjacent to a 42-year-old loblolly pine plantation and two recently clearcut watersheds. Contents of all containers will be composited after each collection for chemical analysis. Lysimeters at two depths at 5 locations will sample the soil solution on a monthly basis. Nutrient loss from each watershed is determined by samples collected weekly below in H-flume equipped with a .61 m Coshockton wheel. Nutrient content of both overstory and understory vegetation as well as the forest floor and mineral soil to a 60 cm. depth has been completed. The effect of acid precipitation on cation losses will be determined by measuring cations in solution.

Progress: 84/01 to 84/12. Objectives of this project are to evaluate effects of acidic deposition, natural leaching, and timber harvest on cation losses from forest sites. Nutrient dynamics have been monitored on a mature loblolly pine stand, a conventionally harvested stand, and a whole-tree harvested stand. During 1984, precipitation, throughfall, stormflow, and soil solution samples were collected, analyzed, and added to the data base previously established. Hydrologic export of cations via stormflow and leaching was greater than that removed in either harvest method. Preliminary results indicate that the majority of the basic cations leached from these sites is due to anthropogenic sources of anions. Sulfate anions account for 40-70 percent of total cation leaching.

Publications: 84/01 to 84/12
NO PUBLICATIONS REPORTED THIS PERIOD.

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THE ROLE OF ENVIRONMENTAL STRESS ON TREE GROWTH AND DEVELOPMENT. 06.092

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CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION & EFFECTS ON AGRICULTURAL & FORESTED LAND & SURFACE WATER. 01.044, 02.023*, 04.019*

CHEMICAL CHANGES IN ATMOSPHERIC DEPOSITION AND EFFECTS ON LAND AND SURFACE WATERS. 01.006, 04.003*, 04.015, 06.017, 40.001*, 67.003*, 68.002*

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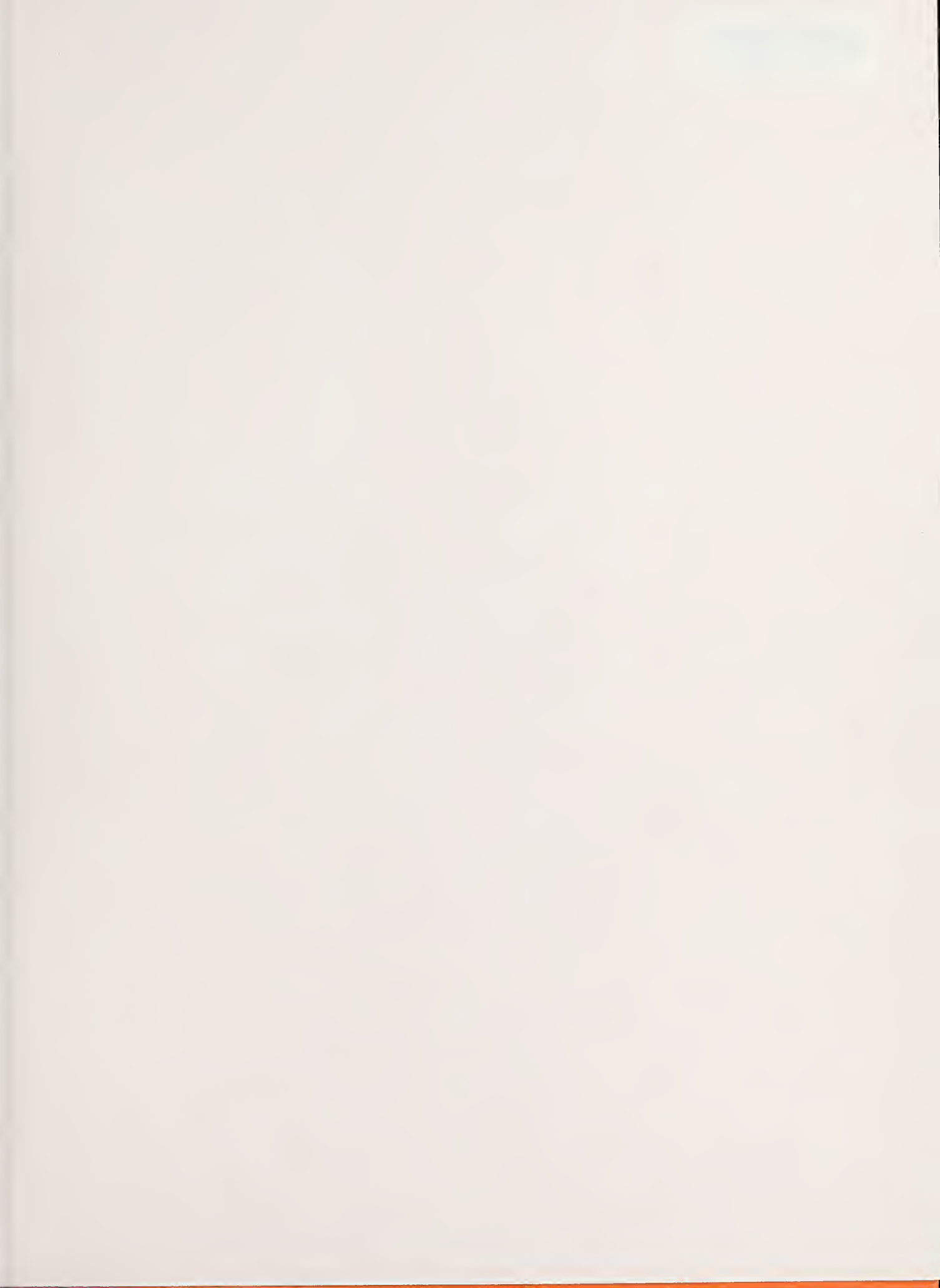
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